

metal finishing

PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING,
GALVANIZING, METAL SPRAYING and all METAL FINISHING PROCESSES

Vol. 6 No. 65 (New series)

MAY, 1960

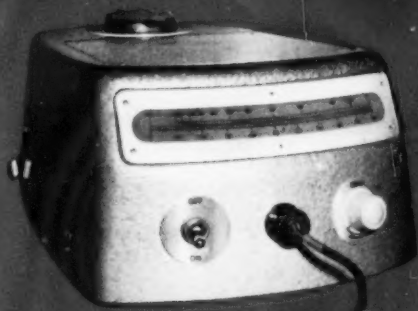
we gave

156

SQ. FT.

to a customer

How much may we give you?



WHERE
COLOUR AND REFLECTANCE
COUNT



Tiona VC — Cream Tone
(Maximum Reflection)

Tiona VN — Neutral Tone

Tiona VB — Blue Tone

TIONA V

specialy developed for use in vitreous enamels



A MEMBER OF
THE LAPORTE GROUP
OF COMPANIES

High density

Free flowing

Easy mixing

High solubility

Shorter smelting times

LAPORTE

Laporte Titanium Ltd., Manover House, 16 Manover Square, London, W.1. Tel. MAYfair 6001/5

INTRODUCING THE ECCO 40

A new, even better spray-gun developed from the highly successful ECCO 30

- * Large air ducts and effective nozzle combinations for greater capacity
- * New packing system for paint needle prevents leakage
- * Ease of operation—comfortable pistol grip... long, two-finger trigger... single hand adjustment of fluid and fan controls
- * Interchangeable paint and air connecting nipples
- * Few parts simplify maintenance



Based on the highly successful Ecco 30, the Ecco 40 has even greater capacity and is easier to operate and maintain. The gun has a light, durable body of modern design and a range of nozzle combinations enabling it to be used for all spray-painting jobs.

USED DAILY AT JAGUARS!

All over the world, the name 'Jaguar' means performance and good looks. At their Coventry works—where craftsmanship is allied to modern production methods—Jaguar Cars Ltd., have introduced Ecco 40 guns to apply the finishes for which they are famous.

A COMPLETE RANGE OF COMPRESSED AIR EQUIPMENT

Atlas Copco manufactures portable and stationary compressors, rock-drilling equipment, loaders, pneumatic tools and paint-spraying equipment. Sold and serviced by companies and agents in ninety countries throughout the world.



Photograph by courtesy of Jaguar Cars Ltd.

Atlas Copco PUTS COMPRESSED AIR TO WORK FOR THE WORLD

Contact your local company or agent or write to Atlas Copco AB, Stockholm 1, Sweden



WHERE
COLOUR AND REFLECTANCE
COUNT



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(Maximum Reflection)

Tiona VN — Neutral Tone

Tiona VB — Blue Tone

TIONA V

specially developed for use in vitreous enamels



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IN ENGLAND

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Laporte Titanium Ltd, Hanover House, 14 Hanover Square, London, W.1. Tel. 845946 8001/2

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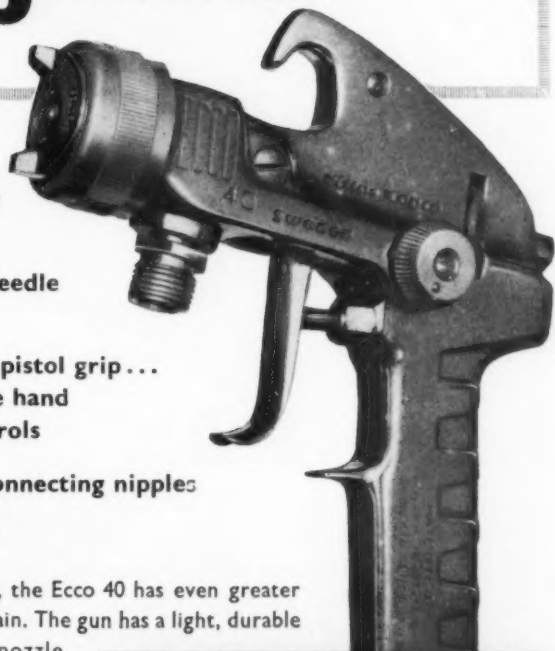
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Contact your local company or agent or write to Atlas Copco AB, Stockholm 1, Sweden



Spray

**with the right gun
and the right
polishing
composition**

**LESS WASTE
COOLER WORKING
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EASIER CLEANING OF THE
POLISHED ARTICLES**

CANNING

Equipment for Spray Compositions :

The Canning Spray Gun is self-cleaning and has been specially designed for liquid compositions. Complete equipment including pressure containers, compressors and manual control or automatic timing units can be supplied.

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Canning Liquid compositions are supplied in a range to cover all purposes and include :—

Liquid Tripoli	No. 3113A — For cutting non-ferrous metals.
Liquid Rouge	No. 3113B — For colouring non-ferrous metals.
Liquid S.S.	No. 3113C — For polishing stainless steels and other hard metals.
Liquid A.2.	No. 3113D — For cutting and colouring stainless and other steels.
Liquid White Finish	No. 3113E — For colouring and finishing non-ferrous metals.

Supplied in easy-to-handle 56 lb. pails which fit inside the pressure container.

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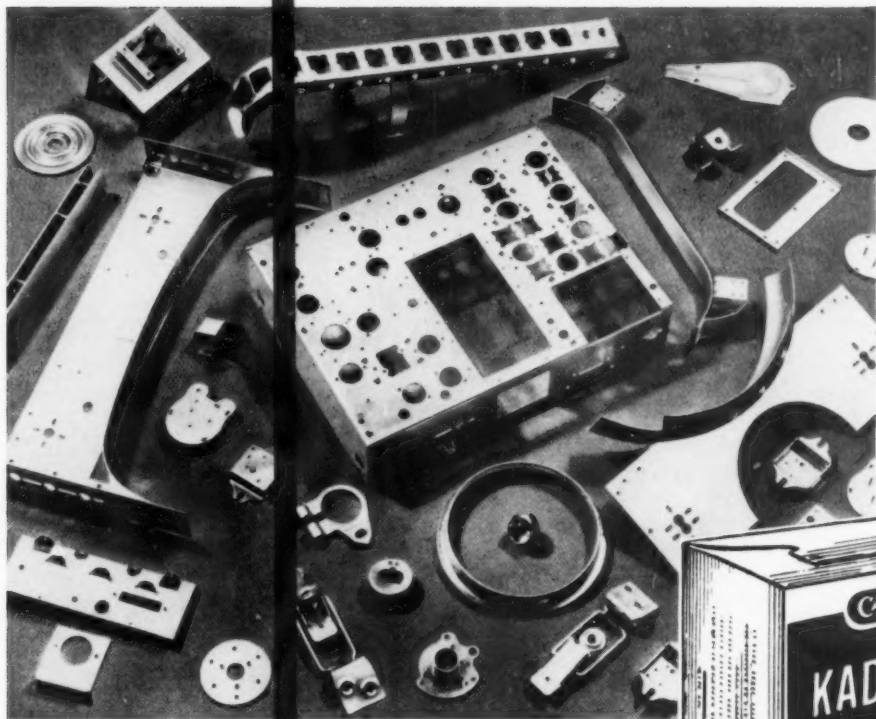
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HIGH SPEED BRIGHT

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Protects and brightens your products

EVEN BRIGHTER WITH NEW KADAMAX GEL

Kadamax High Speed Bright Cadmium provides an attractive rust-proof finish for steel components.

Especially suitable for electrical and electronic apparatus, and for motor and aircraft equipment.

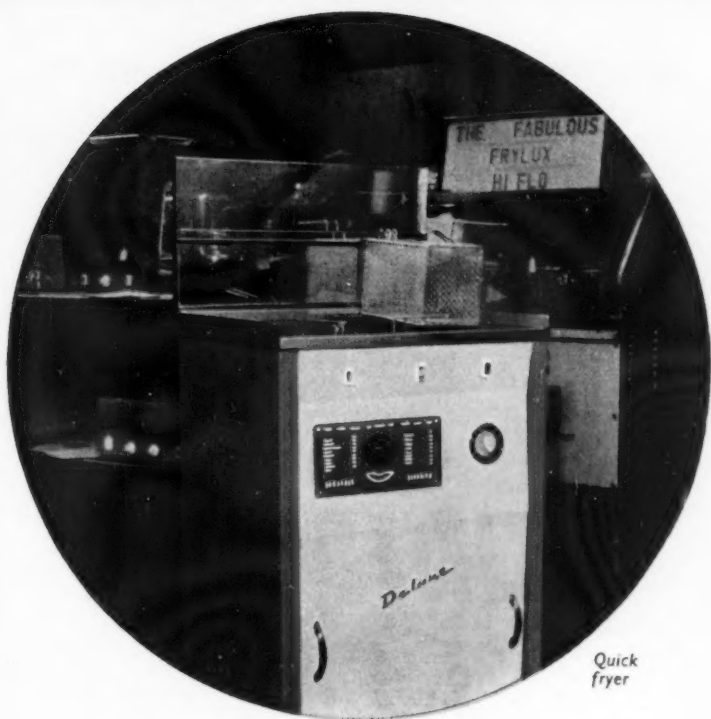
Equally effective for manual, barrel and automatic plating.

Conforms to the requirements of Ministry of Aviation Specification D.T.D. 904.

Ask for Booklet No. 1219 on Canning Cadmium Plating Materials, or for a demonstration of the process at our Technical Centre.



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the smart, NEW, hard-wearing colourful, STEEL SHEETS

P.V.C. COATED

These dispensers, made by Modern Metal Products Ltd., Stoke Newington, attract attention because of their combined attractiveness and practicability.

The 'Artbrite' sheets—available in a wide range of plain, textural and patterned finishes—have a hard-wearing P.V.C. surface on strong, galvanized steel sheet.

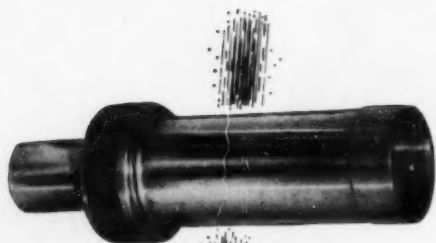
Ask your supplier for equipment built from 'Artbrite' sheets.

Enquiries should be addressed to Specialities Department

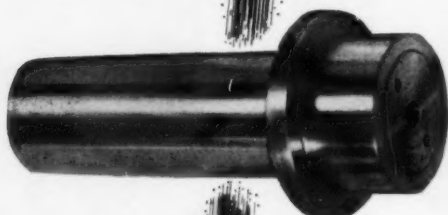
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Limited**

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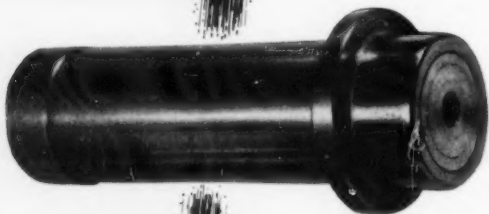
RTB



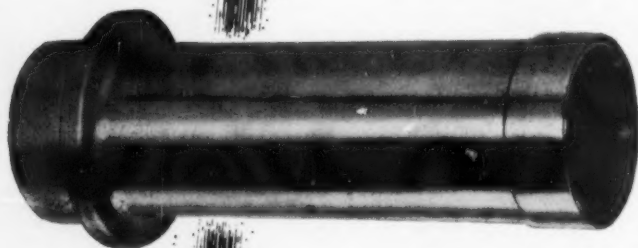
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may, 1960

metal finishing journal

9

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Plastic Coating Material

for **DIP or SPRAY**
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RESISTANT to CORROSIVE ACIDS, ALKALIS and
OTHER CHEMICALS.

5300 Super *Sprayable* PLASTISOL can be applied to all metals. Thickness of 40-60 thou. in one coat, or over 60 thou. in multiple coats. Smooth and uniform deposit obtained even on sharp edges. Ideal for storage tanks, plating vats, exhaust ducting and hoods, fans, office and domestic equipment, etc.

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Wide colour range is offered. Further details on request to—



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BRIGHTEST
FINISH

CHROME

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Potassium Dichromate
Chromic Oxide*

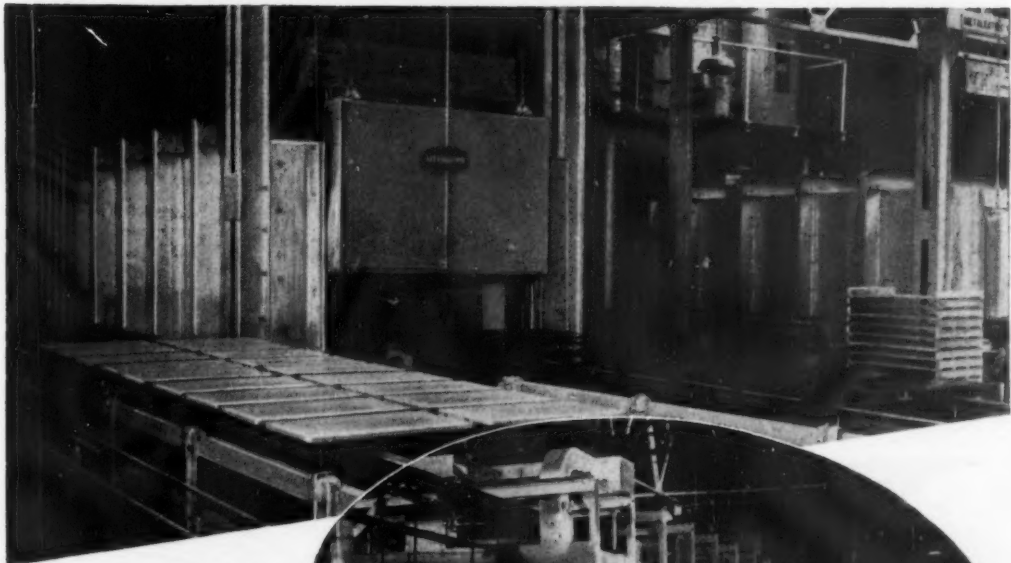


BRITISH CHROME & CHEMICALS LIMITED

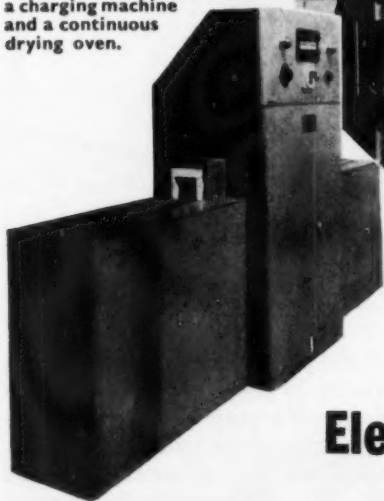
*A member of the
ASSOCIATED CHEMICAL COMPANIES GROUP
Sales enquiries to*

Associated Chemical Companies (Sales) Limited

P.O. BOX NO. 6, LEEDS 1. PHONE: LEEDS 29321/8. GRAMS: ASCHEM. LEEDS.



A twin furnace installation for fusing. The plant includes a charging machine and a continuous drying oven.



This furnace, rated at 10 kW, is used for badge enamelling.



U type fusing furnace for sheet iron cooker parts. Output 1500 sq. ft. (3000 lb.) per hour. Rating 650 kW.

Electric furnaces for fusing

Three examples of METALECTRIC batch and continuous furnaces serving the enamelling industry. All METALECTRIC designs are backed by 25 years experience in furnace building.



METALECTRIC FURNACES LTD.

SMETHWICK · ENGLAND

Degreases

Derusts

Passivates

EURON

EURON

EURON

single operation degreaser,
corrosion destroyer and preventer

For further information about Euron, its capabilities and characteristics, please ask us for the Euron leaflet.

From Roto-Finish come these other surface treatment processes:

- Barrelling and Vibrafinishing for metal and plastics to deburr, descale, deflash, radius, surface blend, polish or lustre.
- Atram phosphating processes.
- Grisiron Alkaline cleaners.
- Mechanical cleaning.
- Ultrasonic cleaning.
- Electropolishing.
- Conversion and protective coatings.

Tell you more about any or all of them? We would be happy to if you write or telephone us.

Euron removes oil and grease, destroys rust and oxides, inhibits further rusting by complete passivation. More than that Euron etches the metal surface to a micro-structure—provides a strong and permanent key for paint. It is suitable for iron and steel, aluminium and other non-ferrous metals. Euron is not only efficient, but also economical, for its fast working rate results in time and labour saving.

Rely on

Roto-Finish

... provide the finishing touch

MARK RD., HEMEL HEMPSTEAD HERTS. BOXMOOR 4700 (PBX)

NEW

An Acrylic Finish with outstanding advantages

*Ideal for all Domestic Appliances
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Superb Finish is required*

Cerakryl

Thermo-Setting

**ACRYLIC
STOVING FINISH**

No other product has these advantages—

- FLEXIBILITY • TOUGHNESS
- IMPACT RESISTANCE
- STAIN RESISTANCE
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- COLOUR RETENTION
- STABILITY - Non-yellowing Whites
- RESISTANCE TO OVER-STOVING

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*we formulate to your individual
requirements . . .*

WE ASSIST YOUR PRODUCTION

Cerakryl

Thermo-Setting

**ACRYLIC
STOVING FINISH**

Details and Quotations on request:

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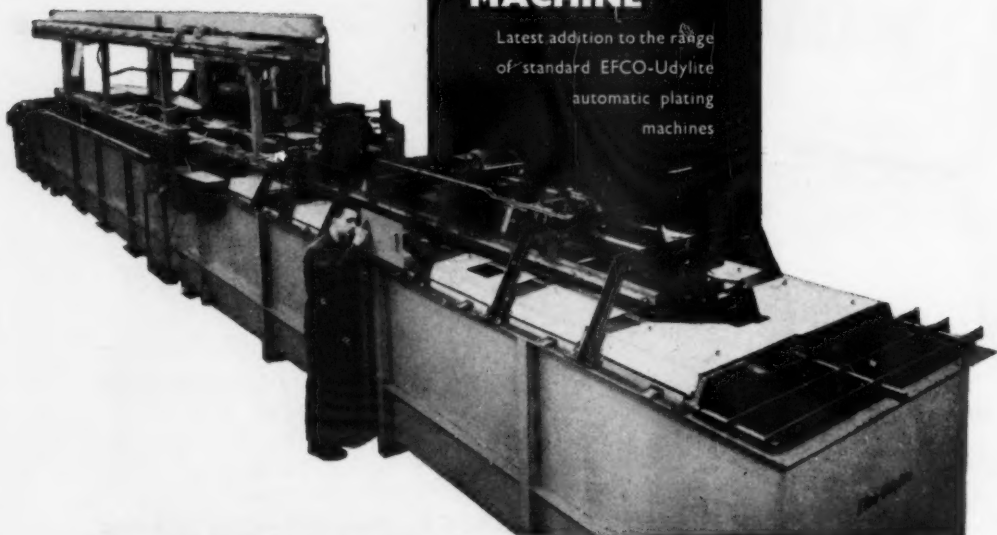
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UNIT

built

**AUTOMATIC
PLATING
MACHINE**

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of standard EFCO-Udylite
automatic plating
machines

**Efco-Udylite 'Cyclemaster'**

A new automatic plating machine built from
standard units and delivered assembled for speedy
site installation. The 'Cyclemaster' processes
from 40 to 100 racks hourly with maximum
rack dimensions of 36" x 16" x 8".

Use
Quality Labels
on your
Nickel Chromium
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OVER 1,000 EFCO-UDYLITE AUTOMATICS ARE IN USE

**ELECTRO CHEMICAL ENGINEERING CO. LTD.**

SHEERWATER, WOKING, SURREY. Woking 5222/7

New Luxol Acrylic Stoving Finish

Almost as hard as Vitreous Enamel!

Here is a new, harder, tougher stoving finish than has ever before been available to manufacturers and processors of domestic and industrial equipment.

In terms of hardness Luxol Acrylic Stoving Finish is almost comparable to vitreous enamel, though considerably cheaper and less liable to chip during assembly. It brings a new improved standard of protection to every type of product. Colours are crisper, cleaner and possess exceptional stability; white is really white and will not yellow with age.

Moderate overbaking has no effect upon Acrylic colours; fewer rejects contribute still further to reducing production costs.

Luxol Acrylic Stoving Finish offers much to a great variety of products.

REFRIGERATORS—Longer, smarter life with its increased toughness plus flexibility, perfect colour retention and new colour brilliance.

WASHING MACHINES—Greater durability with superior stain and detergent resistance.

GAS AND ELECTRIC COOKERS AND WATER HEATERS, ELECTRIC MIXERS—Now more efficient with a finish that is unaffected by temperatures between 320° - 400° F.

HOSPITAL, KITCHEN AND BATHROOM EQUIPMENT, METAL FURNITURE—All improved products with the ability to maintain their immaculate appearance throughout years of use.

Luxol Acrylic Stoving Finish does not interfere in any way with existing production systems.

BRITISH PAINTS LIMITED

INDUSTRIAL FINISHES DIVISION

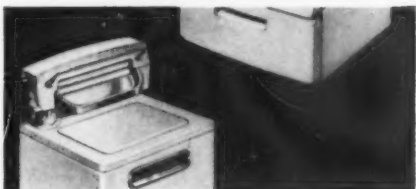
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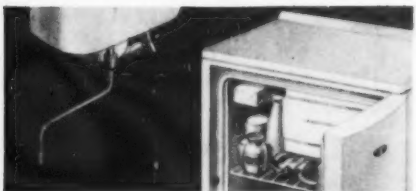
Perfect colour retention



Brilliant clarity of colours



Greater impact resistance



Increased durability



'THREE ELEPHANTS' in every kitchen



... Three Elephant Brand Borates, of course! These pure, versatile products give stronger, finer vitreous enamel finishes and pottery glazes.

PYROBOR (Anhydrous Borax $\text{Na}_2\text{B}_4\text{O}_7$) gives very real savings in the preparation of vitreous enamel and glaze frits, because there is no waste of heat or time in driving off water of crystallization before fusion.

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Subsidiary of American Potash & Chemical Corporation
Producers of: Borax, Soda Ash, Salt Cake, Lithium, Bromine, Chlorates, Perchlorates, Manganese Dioxide and a diversified line of Agricultural and Refrigerant chemicals.

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ELECTRO-PLATING —Chrome, Copper, Nickel, Cadmium, Silver, Zinc, Bright Nickel, Bronze, Tin, etc.

ANODISING —Chromic and Sulphuric Acid processes. Decorative Silver Anodising and Sealing in longest dimensions a speciality.

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OUR FACTORY, equipped with a large, modern and efficient Plant, can undertake all types of Metal Finishing.

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FREE collection and delivery.

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As a Plater you need this booklet

If you produce chromium plating you need to be aware of the Mond campaign to increase confidence in plating standards. It's described in detail in this illustrated booklet 'CONFIDENCE IN PLATING'. Here you'll see the press and TV advertising which will back this scheme in your interests. Right through the scheme runs the theme 'Chromium plating *can* be good!'

Your customers will want to know!

Do you supply the finished goods? Customers will be looking for the coloured labels of plating quality which are part of the Mond campaign.

Do you carry out plating for other people? Then show the special seal of plating standards on your estimates. For this entitles your customer to display the label.

Buyers of cars, household equipment, tools, furniture, and fittings of every type will be looking for plating they can be proud of. Make sure that *you*, as a plater, know all about this new campaign.

THE MOND NICKEL CO LTD

Thames House · Millbank · London · SW1



A new deal for Chromium Plate

**FOR FURTHER INFORMATION ON THE LABELLING
SCHEME COMPLETE AND RETURN THIS COUPON**



*Please send me your booklet 'CONFIDENCE IN PLATING' with
details of how I can join the scheme.*

NAME _____

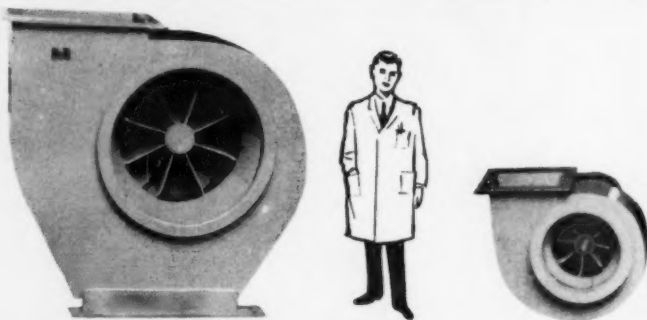
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TGA P1A

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PVC

27" DIAMETER INLET

THE FIRST AND STILL THE BEST

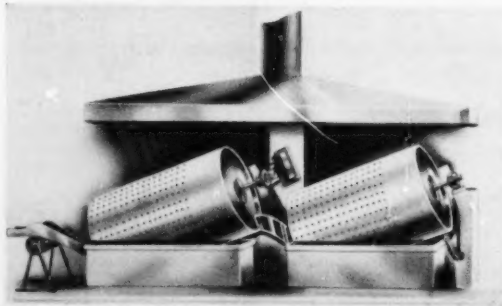
THE PLASTIC FAN Co. Ltd.,

EDWARD STREET, WEST BROMWICH, STAFFS.

West Bromwich 2751

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UNITA PIC PLANT
EXHAUST
SYSTEM**THE EFFICIENCY OF OUR PRODUCTS**

- SAFEGUARDS HEALTH
- IMPROVES PRODUCTIVITY
- REDUCES COSTS

PART OF AN
AUTOMATIC
BARRELLING
PROCESS

this
is
our
business
and
we're
good —
VERY GOOD
at
our
job...



NEW!**'TRISEC'—for stain-free metal drying...**

'Trisec' Metal Drying Assistant is a new product of I.C.I., for use in modified I.C.I. degreasing plants.

'Trisec' is ideal for the rapid drying of metal after aqueous processes, such as electroplating, electropolishing, phosphating, chromating, contour etching, pickling, alkaline de-rusting, etc.

'Trisec' is used as an additive to trichloroethylene (1 part to 80) to displace water from metal articles, leaving them completely stain-free.

Hot rinses, hot air ovens, wiping and sawdust barrelling are therefore eliminated by using 'Trisec' metal drying assistant.

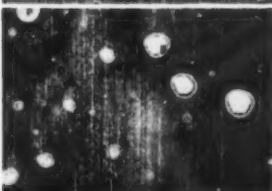
'TRISEC'
metal drying assistant

For literature and other details write to:



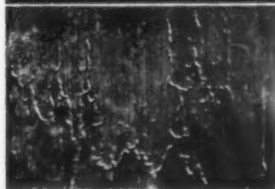
IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1.

DP259



ABOVE Without 'Trisec' Metal Drying Assistant, drops of water on a sheet of metal (top) leave stains on evaporation (bottom).

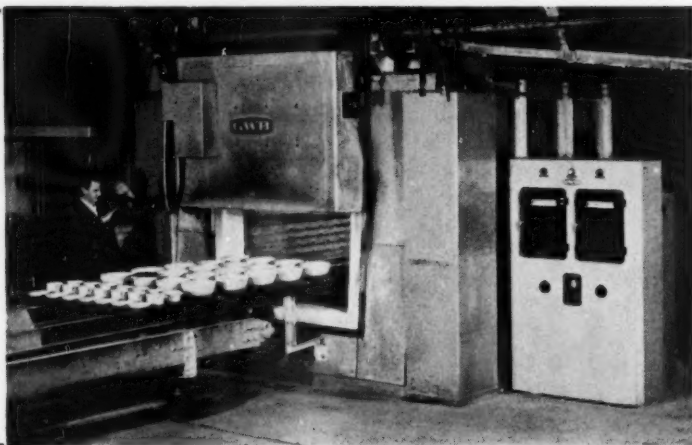
BELOW With 'Trisec' Metal Drying Assistant, the water film is displaced (top) leaving no stains (bottom).



G.W.B. Enamelling Furnace

CUTS HANDLING AND REJECT COSTS

**Elements
and
refractories
have
10 year life**



The demand for high-quality finish and brightness in a wide colour range, plus the necessity to obtain the most economic working life from production equipment, has recently led Izons and Co. Ltd. to install a new G.W.B. electric vitreous enamelling furnace. The furnace, which has internal dimensions of 9 ft. long, 4 ft. wide and 2 ft. high, has a normal operating temperature range of 600-900°C, with a maximum of 1,000°C, is designed for long periods of continuous operation.

High-grade refractories line the heating chamber, which is built of specially moulded element-bricks supporting 80/20 nickel-chromium wire heating elements. These are located in the walls, roof and on the inner face of the door in order to stabilize chamber temperature rapidly after charging or discharging the furnace. The charging machine, which has been in use with an earlier fuel-fired furnace, has been incorporated in the design of the new G.W.B. furnace.

A COMPARISON

A comparative economy and efficiency of the old fuel-fired furnace and the new G.W.B. electric unit is worth examining. In an electrically heated unit there are no products of combustion. In a fuel-fired furnace, even with a built-in muffle which is inevitably semi-permeable, contamination is virtually impossible to avoid. As the combustion chamber is situated beneath the hearth of the chamber, the refractories suffer and frequent rebuilding is necessary. A G.W.B. electric furnace, however, has an

exceedingly long life. An installation of similar type installed in 1933 required its first replacement bricks and some new heating elements in 1942—a very impressive absence of re-lining and “lost production” costs! In addition, the absence of flame action and the smaller temperature gradient of G.W.B. electric furnaces contribute to this longevity. Thus, after being switched off at 6 p.m. the overnight temperature loss (with a working temperature of 760°C) is 100°C. After the weekend the temperature has dropped to 540-550°C.

During the week the furnace is switched on again at 7 a.m. and reaches working temperature in 40 minutes. After the weekend the required temperature is reached in 2 hours. Such switching can be controlled by automatic time switches, and the furnace requires no overnight attendance. The fuel-fired furnace, on the other hand did require overnight and weekend attendance; a desired increase in temperature was difficult to judge and, since there was no form of steady control, it was difficult to maintain any sort of even temperature.

COST OF POWER

While electricity is more expensive in terms of B.Th.U, economies are obtained by the high quality of the product—few rejects—and the remarkably lower cost of handling and maintenance. A G.W.B. electric furnace, because it operates from a 3-phase supply, improves the power/load factors of the supply to the factory, thus reducing the cost of electricity consumed generally.



G.W.B. FURNACES LTD • P.O. BOX 4 • DIBDALE WORKS • DUDLEY • WORCS

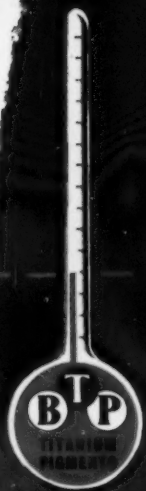
Telephone: Dudley 55455 (9 lines)

Associated with Gibbons Bros. Ltd. and Wild-Barfield Electric Furnaces Ltd.

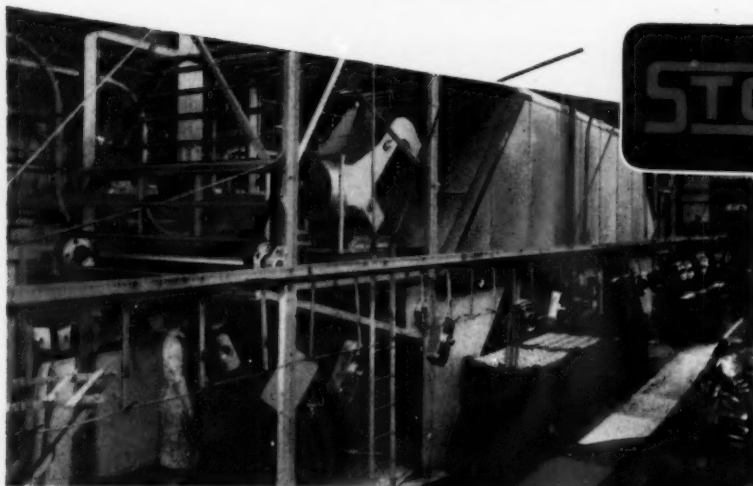
G.W.B. 249

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the cost of producing
ACID-RESISTANT ENAMELS
with
TIOXIDE PIGMENTS

TIOXIDE Titanium pigments
keep down
smelting and firing temperatures
without lowering
the coefficient of thermal expansion.
They give opacity in a thin coat.



British-Titan Products Co. Ltd.
10 STRATTON STREET LONDON W.1



STORDY

**BATCH OR
CONTINUOUS
PLANT FOR
METAL FINISHING**

Batch production or continuous line processing is no problem to the Stordy organisation who have long specialised in the engineering and building of all types of plant for metal pretreatment and finishing. The new Catalogue No. 50 illustrates a wide range of Stordy plant in this field.

Illustrated above: A small type "A" stoving oven, town gas fired and fully air circulated for the finish stoving of a large range of sheer metal and small cast components.

Illustrated below: Part of an installation of batch loading, steam heated, air circulated ovens used in the production of impregnated brake linings.



STORDY ENGINEERING LIMITED
CUMBRIA HOUSE • GOLDTHORN HILL • WOLVERHAMPTON

metal finishing Journal

May, 1960



Vol. 6, No. 65 (New Series)

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Published on the 15th day of each month by

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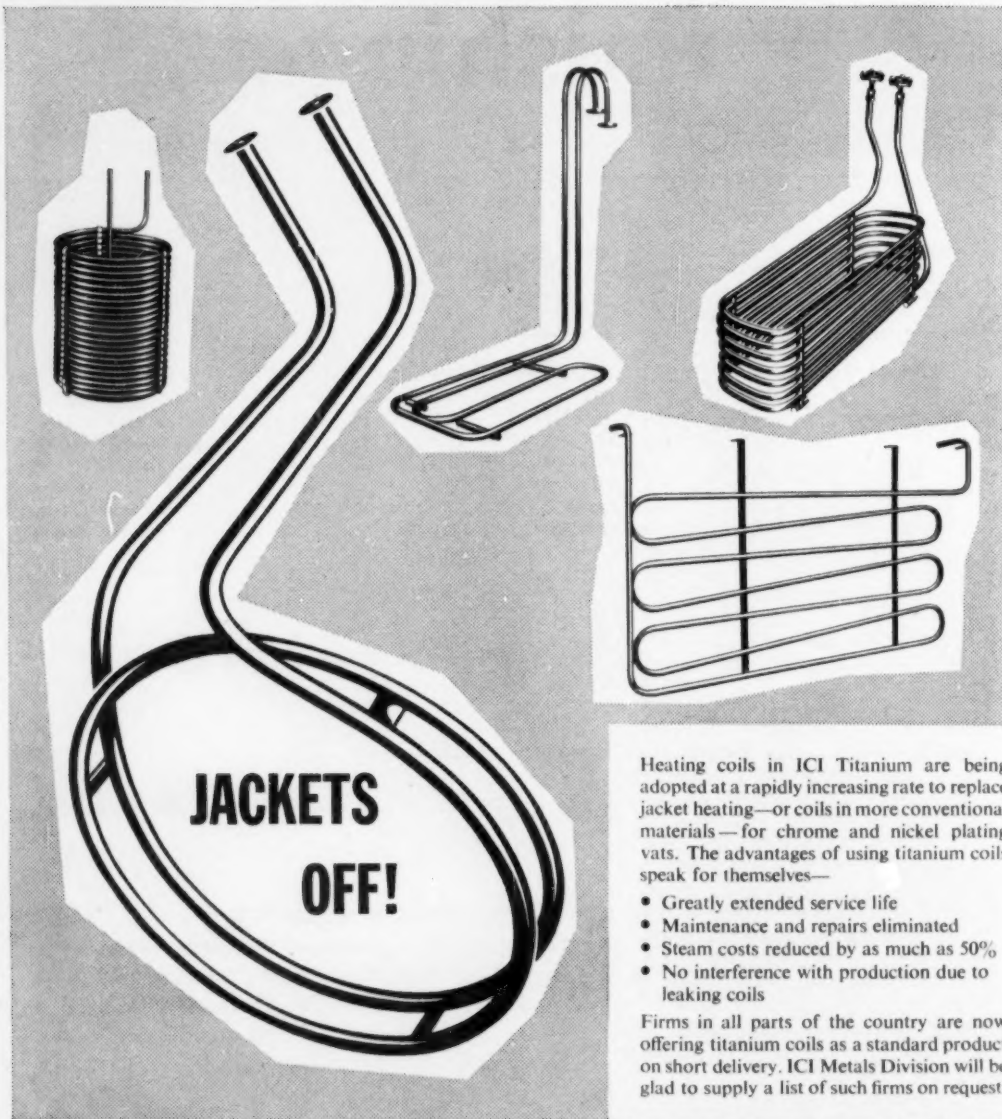
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THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING & ALL METAL FINISHING PROCESSES. THE EDITOR IS PREPARED TO CONSIDER FOR PUBLICATION ANY ARTICLE COMING WITHIN THE PURVIEW OF "METAL FINISHING JOURNAL" AND ALL SUCH ARTICLES ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.

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DO AS YOU WOULD BE DONE BY

WHEN Moses came down from Mount Sinai and presented the Israelites in the wilderness with the Ten Commandments as the fundamental ethical code by which their lives were to be ordered thenceforth, it is reasonable to assume that the reasons for the imposition of such a code had become pressing. Life in the wilderness and the shortages and privations which such a life entails can give rise to a degree of competition which is socially undesirable.

Competitive endeavour, whether it be for the necessities of life or for the luxuries, is the mainspring of all activity, but it is an essential feature of a regulated society that a limit be imposed on the extent to which an individual may pursue his private ends and the means which he may adopt in order to achieve them.

Such limitation is normally achieved in civilised communities by the enactment of a legislative system and its enforcement by a system of penalties which can be imposed on those who are detected in infringements. There are those who believe that failure to observe the requirements of the Mosaic Commandments will ultimately result in retribution being visited on the offender, but as such views are not universally shared it has been necessary to supplement them by more detailed regulations and by more immediate and perceptible punishment for refractory behaviour.

It is however a matter of great difficulty to draw up an enforceable set of civil laws capable of regulating every aspect of individual and communal behaviour, so that there are many courses of action permitted by law which would yet be considered undesirable by generally accepted ethical standards.

This is particularly true in the field of commercial operations. While it is open to anyone to seek redress through legal channels in any case where he has been the victim of a deliberate fraud, there are many practices which, although not in themselves fraudulent as legally defined, do have effects which are not in the best interests of the community.

It has been a not unnatural development of a complex industrial system that organizations or individuals with common interests have formed themselves into associations for the better protection or exploitation of those interests. In the technical sphere this has usually been a welcome and progressive development, but where such association has been for commercial purposes there is a tendency for motives to be more suspect. Nor is it necessarily always the customer who is the sufferer from such associated activity. We recall once hearing a member of a trade association saying that most of his competitors only participated in the deliberations of the association in order to learn the minimum price under which they had to quote in order to get the business.

It is in the light of the foregoing that the recent action of the National Association of Metal Finishers in the U.S.A. in drawing up an industry-wide code of ethics to regulate practices in the trade is noteworthy. This code is published in full in the April issue of our American contemporary "*Metal Finishing*" and it makes interesting and significant reading. It would of course be improper and untrue to suggest that the undesirable practices which the code is designed to repress are rife on either side of the Atlantic, but infringements of good trading ethics are certainly not unknown, and any attempt to foster and promote a more responsible attitude which can only redound to the credit of the industry, must be warmly welcomed.

Talking Points

by "PLATELAYER"

TOPICAL COMMENT
FROM THE MAIN
LINES AND SIDE
LINES OF METAL
FINISHING

SEASIDE THOUGHTS

IRRESPECTIVE of the technical merits of the proceedings at Scarborough last month, the I.M.F. Conference showed that it is now fully entrenched as the European—if not the world—forum of the metal-finishing industries. The remarkable fact that about 400 delegates from 14 countries (and, incidentally, the five Continents) should have found it worth while to travel to a somewhat remote Yorkshire town to be present, is no small measure of the importance which is attached to it in many quarters. Yet only a few years ago, a visitor from abroad was so rare that he was assured of a seat at the top table! Some may deplore the preponderance of supply interests, but the fact remains that the progress of the industry is largely tied up with what supply companies have to offer. It is they who must keep abreast of developments and do the research to ensure that they are able to meet the needs of their customers in a fiercely competitive field. Evidently, the I.M.F. Conference seems to be useful in this way, otherwise they would not go to the trouble and expense of being represented in such strength. At the same time, manufacturing concerns must also find it of value, as can be seen from the fact that one Continental electrical company alone sent five delegates.

Whatever one may think of the Conference (and many unkind things have been said from time to time), it is a remarkable phenomenon, and there can be little doubt that it will continue to grow still further.

This is closely tied up with the fact that so far there is no equivalent to a meeting of this kind anywhere on the Continent of Europe, despite the advent of the Common Market. It might have been expected that this development would have led to greater integration and hence to more technical associations, but these still remain largely a characteristic of the English-speaking nations.

As so many foreign visitors now attend the ordinary annual conferences of the Institute, one is prompted to wonder whether the Sixth International Conference on Electrodeposition and Metal Finishing proposed for London in four years time may not by that time have become superfluous.

LABOUR LOST

A RECENT paper on exposure tests carried out on nickel-plated steel in Germany has been published, from which the authors draw

conclusions on the relative merits of copper undercoats, steel quality, cleaning procedures and so on. The surprising thing about the report, however, is that the work has been done on nickel-plated steel without a chromium coating, which in effect invalidates it completely so far as practical considerations are concerned. Nickel-plating is almost invariably used as an undercoat to chromium and it has, by now, been thoroughly established that exposure tests on nickel-plate which has not been chromium-plated under carefully controlled conditions can in no way be related to the subsequent performance of a nickel-chromium finish.

It is a pity that an extensive series of exposure tests which might have been of considerable interest has been vitiated by a lack of realisation by the authors of the importance of the chromium layer.

GENERAL POST

THE last quarterly Board of Trade returns show that £11 million worth of steel was imported into the U.K. to make up for the shortages which are currently being encountered by the steel-consuming industries. This is an all-time record.

However, it is interesting to note that this is almost exactly equal to the value of steel which was exported during the same period.

All this, of course, makes for great happiness all round, for the prosperity of mankind appears to be proportional to the amount of stuff being moved around from one place to another.

"PAYOLA"

ONE of the problems facing both suppliers and customers in industry is to decide what constitutes an unfair inducement to show favour and what is normal hospitality. It is very necessary to strike a balance, because excessive rectitude can so easily degenerate into churlishness.

An American dictum which is intended to act as a rough-and-ready guide in these matters says: "If you cannot eat it or drink it in one day or at one sitting, it must be refused." But perhaps this is a counsel of perfection.

pHoney pHilology

WE were intrigued to read of a new detergent which is being marketed by Bayer Products for the pharmaceutical trade. It is to be called *pHisoHex*; but how does one pronounce it?



THE METAL FINISHING CONFERENCE

held in
SCARBOROUGH
April 27-29,
1960

A Report of the Annual Conference of the INSTITUTE OF METAL FINISHING

METAL finishing, although a large and all-pervading technology, is a somewhat diffuse industry, which includes among its practitioners many divergent interests. Nevertheless, to judge by the steady growth over past years in the attendance at the Metal Finishing Conference, these interests are evidently being catered for satisfactorily by the organizers of this function.

New ground was broken by going to Scarborough for this meeting, the twelfth of its kind to be held since the war, and the registration of over four hundred and thirty delegates, the great majority of whom attended the full term of the Conference, constituted a new record in the annals of the Institute.

The Conference was formally opened on the morning of Wednesday, April 27, by the Deputy Mayor of Scarborough, who was received by the President of the Institute, Mr. A. A. B. Harvey, supported by the immediate Past-President, Dr. T. P. Hoar and the Honorary Secretary, Dr. S. Wernick. On the evening of that day the delegates and their ladies were entertained by the Corporation of Scarborough at a Civic Reception and Dance, at the Grand Hotel.

The social activities of the Conference culminated on the final night, Friday, April 29, with the Conference Dinner and Dance held at the Grand

Hotel. The hotel dining room with its superb view of South Bay provided an admirable setting for this function at which the principal guest was Mr. Richard Summers, president of the British Iron and Steel Federation, who proposed the toast of the Institute. The toast was replied to by the President, who also proposed the toast of the guests and kindred societies. The reply to this latter toast was made by Mr. J. W. Barter, M.P.

The Institute was fortunate in enjoying the good weather, which is now almost traditionally associated with its annual Conference, and the facilities provided by the Grand Hotel, at which the technical sessions were staged and where the majority of the delegates were accommodated, contributed not a little to the undoubted success of the meeting. Attendance at all sessions was good and most of the discussion was of a high order. The usual display of technical exhibits was staged under the control of Mr. E. Spencer-Timms, and if these were rather less stimulating than in former years, it can only be attributed to the fact that exhibits are only accepted which are illustrative of the themes of papers presented at the sessions, and the present programme did not necessarily lend itself to anything particularly significant from the exhibition point of view.

That the Conference was the success, which it

was generally acclaimed to be, can in the ultimate analysis only be attributed to the painstaking and detailed work of the Social Sub-Committee under the chairmanship of Mr. J. Pigott, to the smooth administration of the technical sessions by the Session organizer, Mr. R. T. F. McManus, to the herculean and untiring efforts of the small band of workers at the I.M.F. Office, to the effective and well-balanced programme put together by the Technical Sub-Committee led by Mr. H. C. Castell, and finally and by no means to a lesser degree, to the very noticeable spirit of good fellowship which characterized all delegates who were present.

In the pages which follow we present brief abstracts of the technical papers presented at the Technical Sessions on the first day, together with a preliminary report of the discussion which followed their presentation, interspersed with some random studies by our roving cameraman of some of the delegates in a variety of moods. Reports of subsequent sessions will be published in future issues of this Journal. The full text of the papers has been, and is being, published, together with the authoritative version of the discussion, in the Transactions of the Institute of Metal Finishing.

ABSTRACT NO. 1

METHODS OF OBTAINING IMPROVED OUTDOOR CORROSION RESISTANCE WITH NICKEL AND CHROMIUM PLATE

by H. Brown* and D. R. Millage.*

IN this paper the outdoor corrosion resistance of chromium-plated, polished Watts nickel is compared with that of bright nickel; a number of composite plates are also considered. These deposits are considered from the point of view of producing more corrosion-resistant coatings for zinc-base diecastings on which premature failures usually occur in large cities where salt, especially acidic salt, used for de-icing roads, sets up a galvanic cell making the chromium layer cathodic while the underlying metal (usually nickel) exposed in the pores or stress cracks of the chromium becomes the anode. These conditions favour rapid corrosion pitting.

In effect very little nickel is corroded away, but, since the electrochemical attack is concentrated at dispersed parts, there is rapid corrosion penetration to the basis metal. Corrosion pits also grow laterally, so increasing the nickel to a thickness

greater than 0.5 mil gives more than a proportional improvement in corrosion protection.

Also, very small lace-like stress cracks in the chromium are less harmful than pores, and the more uniform the rate of attack on the underlying metal the duller will the surface become with time of exposure.

Unless a low-stress, pore- and crack-free bright chromium plate can be developed without adversely affecting hardness, it will not be possible to decrease the nickel thickness without sacrificing the best insurance against corrosion with Ni + Cr and Cu + Ni + Cr systems, i.e. the nickel thickness will still be the key factor.

An alternative to thicker nickel is to use a basis plate less susceptible to corrosion, e.g. using a Watts bath. However, the final factor is the ratio of cathode to anode area, i.e. the distribution of porosity in the chromium plate.

Methods of Improving Protection

Thicker Bright Crack-free Chromium

The main difficulty with increased thicknesses of chromium is the fact that the visible stress crack pattern is not usually acceptable, even though protection is improved. In fact porosity is not small enough to give outstanding improvement until a thickness of about 0.8 mil is reached.

In general 0.03 mil final bright crack-free chromium on the usual thickness of nickel and Ni + Cr coating does not give the improvement necessary for outdoor exposure when there is likely to be contact with salt. With 1.5 mil nickel plate and especially with 1 mil Cu + 1 mil Ni plate, the 0.03 mil crack-free Cr has shown more consistent improvement. With dual or duplex nickel, especially on copper, the use of 0.03 mil of crack-free Cr has been reported to result in a definite improved performance in static outdoor exposure tests as well as in accelerated tests.

Duplex or Dual Nickel

With the advent of the Corrodokote and Cass tests, the use of the duplex nickel system, which easily passed these tests, increased greatly in U.S.A., for both steel and zinc-based components destined for applications involving severe outdoor corrosion. The use of duplex nickel, however, does not allow a reduction in nickel thickness, but a high ductility after chromium plating is a very important feature. Such a system allows a thick nickel deposit (1.5 mil minimum) to be used without the risk of brittleness. Duplex nickel deposits do not, like 0.01 mil chromium-plated polished Watts nickel or semi-bright sulphur-free nickel, become dull on exposure in an industrial atmosphere.

In general the duplex nickel system has given good service results and is now well established.

* Udylite Research Corp., Detroit 11, Michigan, U.S.A.

Dual or Duplex Chromium

This consists of a bright crack-free layer followed by a coating of bright, very finely cracked chromium of about equal thickness. The total thickness must be at least 0.025 to 0.03 mil on the significant areas, otherwise improved corrosion protection will not be obtained.

In general a duplex chromium system on nickel or copper and nickel plate offers great improvement in protection of the basis metal against outdoor corrosion, but perhaps one of the remaining problems is the rate of dulling in service.

Cr + Ni + Cr Composite

This is capable of offering the best atmospheric corrosion resistance although no commercial operation of such a sequence of plating has yet been used. However, pilot plant tests have been made. One of the virtues of this "sandwich" plate is that it allows the use of the most corrosion-proof chromium, *viz.*: the crack-free deposit obtained from the higher-temperature baths.

In the case of zinc-base materials excellent outdoor service can be obtained with 0.3 mil copper, + 0.03 to 0.05 mil semi-bright chromium + 0.8 mil bright nickel + 0.1 mil bright chromium.

ABSTRACT NO. 2

FACTORS INFLUENCING THE CORROSION RESISTANCE OF DECORATIVE PLATING ON ZINC-ALLOY DIECASTINGS.

by Osman J. Jones,* V. E. Carter,*
and J. Edwards

THE first part of this paper deals with the influence of variations in the structure of the zinc alloy and the presence of typical casting defects on the durability of the plated casting, and the

second part deals with the use of thicker chromium plated layers and the effect of substituting direct nickel for the copper undercoat.

Test specimens for part I were prepared from Mazak 3 alloy and these were given to two industrial platers who were asked to plate with $0.3 + 10^{-3}$ in. copper, various thicknesses of nickel and $0.01 + 10^{-3}$ in. chromium. Each also plated the same number of commercial die-castings to the same minimum thickness specifications.

Specimens used for laboratory plating were also of Mazak 3 and consisted of various die-castings, rolled sheet and gravity castings.

For Part II of the work the specimens were a car door handle with a sharp recess between the push-button surround and the main body of the handle, and a flat plate with two edges turned through 45 deg. Full details of cleaning and plating procedures are given in the paper, together with the method of determining deposit thickness, conditions of exposure (which included industrial and marine sites), assessment of corrosion, etc.

Results

Although complicated by the effects of variations in the thickness of chromium, exposure tests on zinc alloy fabricated in various ways and plated with Cu, Ni, and Cr by industrial platers and in the laboratory provide strong evidence that the durability of the plate is independent of the structure of the basis metal. In any case, it can be said that structural variations have less effect than variations in Cr thickness.

Diecastings prepared for plating by a faulty procedure and showing considerable blistering before exposure performed no worse in the exposure tests than properly plated diecastings. This confirms the view that failure of plated diecastings in service is mainly due to the corrosion of the basis

* B.N.F.M.R.A.

Mr. A. A. B. Harvey, (left),
President of the Institute in con-
versation with Dr. J. E. Garside,
the Hon. Treasurer.





Dr. T. P. Hoar, (left) past president of the Institute, considers a knotty point in discussion with Mr G. A. Curson (Sales Manager, F. W. Berk and Co. Ltd., Schori Div.)

metal following penetration of the coating. This process is for the most part uninfluenced by the surface structure of the casting and the presence of minor defects which are not sufficiently disfiguring to cause rejection of the plated article.

With conventional Cr, relatively small variations in thickness can have a major effect on the rapidity of breakdown. Very thin deposits are very porous and cause the early development of closely packed pits, but the rate at which they penetrate the nickel layer is slow, delaying blistering but dulling the coating.

Thicker deposits ($0.01 + 10^{-3}$ in. minimum) are less porous and retain their brightness, but the fewer pits produced penetrate more rapidly and blistering occurs within a short time.

Deposits of $0.02 + 10^{-3}$ in. are usually partly cracked and blistering is reduced but not eliminated in the uncracked areas. Corrosion of the nickel under the cracks is slower than pitting, but may be more rapid if the chromium is thicker.

Corrosion is slow when the crack pattern formed is fine and closely packed, but there is a considerable loss of lustre. The type of crack pattern produced appears to be a function of the Cr-plating solution, and the conditions of deposition, but other factors such as the shape of the article and the nature of the metal surface may also be contributory.

Similar considerations apply to crack-free Cr, with the important difference that the thickness at which cracking occurs is raised by a factor of two. Thus there is a reasonable range of thickness over which the Cr is only slightly porous but uncracked.

The extent to which the benefits of thicker Cr can be realized depends largely, however, on the shape of the articles being plated and the optimum thickness of Cr from the point of view of corrosion resistance may prove to be greater than that permitted by practical and economic considerations.

However, Cr thickness could be increased to give greater durability without detriment to appearance. A suitable minimum thickness is $0.03 + 10^{-3}$ in., but excessive cracking should be avoided and complete coverage with a fully bright finish should be retained.

All the tests have shown the beneficial effect of increasing Ni thickness.

Tests in Part II are not yet complete and duplex deposits are also being prepared for exposure tests.

The substitution of direct Ni for Cu as the undercoat does not appear to have improved corrosion resistance.

DISCUSSION

MR. D. M. WALKER (Wilmot Breeden Ltd.) said that *Brown and Millage* suggested that it was the recessed areas, where the metal was thinnest, that failed first, but recent observations on many motor vehicles did not confirm this. It might be true of hub caps, of which his firm had no experience, but on other parts of automobiles the danger areas were the large, almost horizontal flat surfaces. Many vehicles had been examined during the past winter and it had been found that it was on these surfaces that deposits from industrial atmospheres took place. Examination after a fall of snow in Birmingham showed that the snow was acid and the effect on the plating was to make it appear like a currant cake, with tiny black specks of materials which damaged both the plating and the paintwork. Two days after the snow there had been smog, and when vehicles were examined it had been found that when these specks were removed from paint or nickel they left a brown mark behind. He suggested, therefore, that it was the flat surfaces which had to be watched.

The authors suggested new "sandwiches" such as nickel + chromium + nickel + chromium, but it might be found more profitable simply to put

a little more nickel on. They also suggested that increasing the nickel thickness gave an increasing rate of protection which was not in direct proportion but rather better. The experience of his firm was that over a certain thickness the law of diminishing returns began to operate. Fortunately the salt conditions in this country were not so bad as in the United States, so that the same conditions had not to be faced here.

Turning to the paper by Jones, Carter and Edwards, he hoped it would not be inferred from the introduction that there was nothing wrong with die castings. Dr. Edwards was to attend a meeting of die-casters in Italy in the near future and ought not to indicate that the position was satisfactory. Mr. Walker did not think that it was. His company dealt with about four million die castings a month and in the course of doing so inspected them at various stages. Their inspectors had a great deal of experience and it was possible to rely on their judgment, but it was difficult for laboratory workers to make a correct assessment. The very fact that die-casters were spending large sums in an attempt to improve their castings seemed to refute the suggestion that there was nothing wrong with them.

He found the exposure tests described a little surprising. Some of the exposures were very short and none of the parts appeared to have been exposed in the positions in which they were used. That was a very important point, because in a motor car the corrosion was usually in a specific place associated with the position in the vehicle,

and if the same part were taken and hung upside down there would be a different corrosion pattern. He suggested that the roof of Euston station, which the authors said was grim, was not so grim as Birmingham, because although there was a railway there were no chemical processes on a large scale going on. Places such as Birmingham and Sheffield were much worse than the roof of Euston station. He sympathized with the authors because with this type of work it was not possible to repeat the test. Looking at the samples which were displayed, there was a peculiarity on one of them and he gathered that they had had no more than six for that assembly. It was hardly possible to draw correct conclusions from such a small number.

Direct Nickel Plating

He was surprised at the difficulty they had had with direct nickel plating and hoped it would not be felt that, because the B.N.F.M.R.A. had been unable to get proper adhesion, direct nickel was no use. His company had supplied two million components in the last 18 months with direct nickel plating and had had no trouble with adhesion. It would be a year or more before it was possible to say whether or not they were any good.

It was unfortunate that the two papers were being given to a meeting of electro-chemists and platers. In the first paper great emphasis was laid on the shapes of components, and the industry, the users and everyone else would benefit if papers

Mr. Myron B. Diggin, (Technical Director, Hanson-Van Winkle-Mumming Co.) is received by the Deputy Mayor and Mrs. Hodgson and the President of the Institute at the Civic Reception given to the Conference delegates by the Corporation of Scarborough.



of that kind were given to the stylists and the designers. He did not think that a single stylist had ever been a member of the B.S.I. and other committees that decided whether to have this or that thickness, and there could be no doubt that complexity of shape affected the process. He hoped that some work would be done on the distribution of nickel on complex shapes; it seemed to him that that was probably the most direct way of getting a better result. He looked forward to the day when instead of a thickness of 2/1 it would be possible to have 1/1 all over.

MR. T. M. SUCH (W. Canning and Co. Ltd.) considered that the biggest improvement of all would be brought about if only B.S. 1224 was complied with. As he saw it, there were two main criteria for various nickel-chromium systems which might be used to give improved corrosion resistance over a conventional bright nickel and chromium flash. First, it must be assumed that if a bright finish was required it must remain bright in service, as well as protecting the basis metal. If the original bright coat became dull it no longer fulfilled the requirement of being a decorative coating and one might as well use a clear passivated zinc plate with its initial lustre. Second, the process of applying the system must be a practical one to use in the industrial plating shop as well as in the laboratory. It was essential that it should be possible to use it on present automatic plating plant without major alterations. A system which required a different process sequence, which meant a good deal of new equipment, might be useful in the future, but urgent action was required to produce better corrosion resistance on articles which were being plated now.

The only two processes mentioned in the two papers under discussion which met these criteria of maintenance of lustre and practicability were duplex nickel and crack-free chromium. He agreed with *Brown* and *Millage* that duplex nickel on steel did not show up so well in an industrial atmosphere as accelerated corrosion tests seemed to suggest; there was a significant improvement, but not so great as might be hoped for, though the improvement given by duplex nickel was more marked when specimens were exposed to marine atmosphere. Unfortunately, sulphur dioxide was a more important pollutant than salt in an English winter. The acetic-acid salt-spray test could be misleading as a research tool because of this, and the sulphur dioxide test was more helpful in this respect.

Merits of Crack-free Chromium

Brown and *Millage* held different views on the merits of crack-free chromium from those of *Jones*, *Carter* and *Edwards*. Although the work with which Mr. Such had been associated had been on steel and not zinc alloy, he agreed with *Jones*

et al. on the benefits of crack-free chromium, which was superior to duplex nickel in industrial atmospheres if a sufficient thickness was applied, but he felt that the authors of the first paper were unduly pessimistic in saying that no outstanding improvement was given by crack-free chromium until a thickness of 0.08 mil was reached. That might be so in Detroit, but not in Birmingham, where 0.03 mil gave marked benefit and the results commercially merited the description of outstanding when compared with those given by the conventional 0.01 mil. It was true that 0.045 was better and 0.06 better still, but the results which they had obtained did not indicate that it was worth going beyond the latter figure.

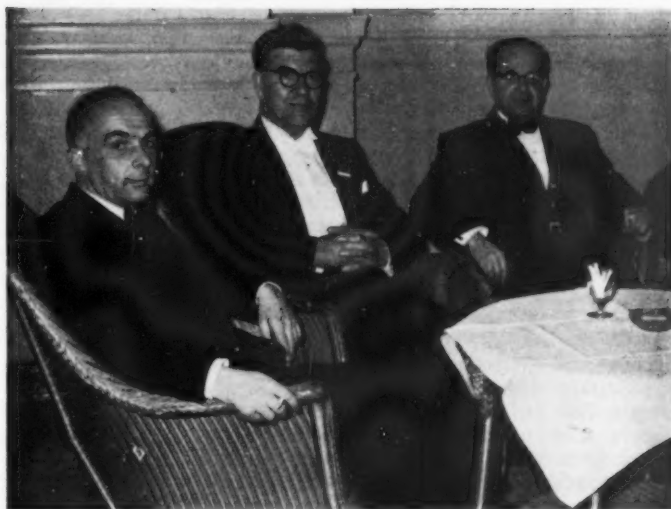
The corrosion found on plated steel panels on the roof compared closely with that in the sulphur dioxide test provided that this test was carried on for longer than the 24 hours specified in B.S. 1224. It took 48 hours to distinguish between the good and the excellent.

For more concentrated chromic acid solutions than the 340 gm. per l. used by the authors of the first paper, for example 450 gm. per l. with a chromic acid/sulphate ratio of about 140/1, the temperature of plating could be brought to the more realistic figure of 46°C. (115°F.) and the current density dropped to a more practical figure of 150 to 200 amp. per sq. ft. He submitted that the use of such a solution with a plating time of 7½ to 10 min. was the cheapest, easiest and most easily available way by which increased corrosion resistance could be given to nickel and chromium on plated articles not in the distant future but now. Nevertheless duplex nickel and crack-free chromium should not be regarded necessarily as competitive, but rather as complementary. Why not use duplex nickel followed by crack-free chromium, for example, and so get the best of both worlds?

Finally, why did *Brown* and *Millage* prefer the use of a high ratio sulphate-containing solution to one containing silico-chloride for depositing an initial layer of chromium in their composite deposits?

MR. C. H. SAMPLE (International Nickel Co. Inc., New York), whose remarks were directed primarily to the first paper, said that the authors had relied very heavily on galvanic effects between chromium and nickel to explain what they had observed. No one doubted that galvanic effects did occur and that they were important, and there was no doubt at all that the anode-cathode area relationships were extremely important. He felt, however, that there was a tendency for oversimplification in this respect and that a good many assumptions had been and probably still were being made. He hoped that the authors would, in their laboratory, pay a good deal of attention to some electro-chemical measures to see whether

Left to right : Mr. H. C. Castell, Chairman of the Conference Technical Sub-Committee ; Dr. J. E. Garside, Hon. Treasurer and Dr. S. Wernick, Hon. Secretary of the Institute.



or not they bore out what they had assumed to be the explanation of the observations which they had made. What was important, of course, was that the quality of decorative plating had certainly been improved, regardless of the mechanism, but he felt that more rapid strides could be made if the mechanism involved was known.

Galvanic Effects

In that connexion and by way of illustration he showed three slides. He found it difficult to believe that the effects shown in the first slide were due entirely to the galvanic effects which the authors mentioned ; there was, he thought, some other mechanism at work. The slide showed 0.0015 in. of a particular bright nickel plated directly on steel without any chromium. It also showed the same plating after buffing. The plated panels had been exposed for 7½ months at Kure Beach, North Carolina. There had been no rust spots for a few weeks and then some began to appear. The corrosion rate of nickel at that exposure was almost negligible. The second slide showed replicas of the first panels but plated with 0.01 mil of conventional chromium. There was no doubt that there was some adverse effect of chromium plating on this very fine-grain, highly lustrous bright nickel. The reason was somewhat obscure, but he could not bring himself to believe that this difference in behaviour was due solely to the galvanic effects which had been referred to.

In his laboratory at New Jersey his colleagues were doing a good deal of work on electrochemical *i.e.* galvanic effects, between chromium and nickel and between nickel and steel. This work had not been completed, but a good many interesting findings had been made. Chromium was not

always cathodic to nickel and in very many instances the reverse had been found to be true. In any case the potential difference between chromium and nickel was not very great. It was hoped to publish this work in about a year's time. Some observations of interest had also been made at the National Bureau of Standards, where simulated cells between nickel and chromium had been set up and attempts made to measure the micro-currents involved. There again it had been found that in a good many cases the chromium was anodic to the nickel and in a good many others there was almost no potential at all. In others the nickel was anodic to the chromium, but the potential difference was not large and certainly not of the standard e.m.f. series or the so-called galvanic series.

His third slide bore out what had been shown previously, that benefit was obtained by the use of duplex nickel. The slide showed 0.002 in. of duplex nickel with conventional chromium plating, and 0.002 in. of regular bright nickel with conventional chromium plating. The panels had been exposed at Kure Beach for eighteen months and it was evident that the duplex nickel was much superior. This seemed to be a practical answer to the serious problem which had faced the industry over the years, but again he doubted that galvanic effects alone could account for the big difference found.

Mr. M. B. DIGGIN (Hanson-Van Winkle-Munning Co., New Jersey) commented on the subject mentioned by Mr. Sample, the theoretical study of what was responsible for increased corrosion protection, and showed a number of slides. The first showed the galvanic series, and he pointed out that it was possible to have the same metal

(nickel in this case) is an active and passive state, and if potential measurements were made between the two a difference in voltage would be found. The second slide showed the experimental set-up for determining the potential. Foil was plated with a sulphur-free semi-bright nickel and with a sulphur-containing bright nickel and the potentials were determined. It was possible to couple the two together in an electrolyte and measure the potential difference, and this potential difference would indicate the difference in activity of the two foils. In the graph shown in his third slide, the upper curve was for the sulphur-containing bright nickel and the lower curve for the sulphur-free semi-bright nickel. On the right the millivolt potential was plotted against time. It took some time for these foils to come to equilibrium, so that readings had to be taken over a period of time. It required up to 20 minutes to come to equilibrium. The shape of the curves depended a great deal on the composition of the solution from which the deposit was made; for instance, the top curve could be raised considerably by using more organic brightener in the bright nickel solution, but that was a very bad thing to do, because the bright nickel was anodic to the semi-bright nickel underneath, and if the potentials were too far apart there would be exaggerated corrosion of the bright nickel with unsightly spots developing.

As an indication of the difference in activity of these two types of foil they could be put in a warm 5 per cent acetic acid solution and it would be found that the semi-bright nickel would remain sometimes for hours without perforation, whereas the bright nickel would perforate very readily. As an experiment to show the difference in activity a sulphur-containing foil had been produced with a very high sulphur content. About 0.003 per cent of sulphur was the maximum permissible in a semi-bright so-called sulphur-free nickel, but by increasing the organic sulphur compound in the solution it was possible to produce a foil with considerably higher sulphur content. If the foil, which was brittle, was then pulverized and put in a solution used for etching nickel it would react with almost explosive force, whereas the sulphur-free nickel in such a solution remained almost inert, i.e., the attack was very slow.

Subsequent slides showed the results of the test on the duplex nickel and the penetration from the bright coating to the semi-bright, the same effect after atmospheric exposure for about two years, and some of the pits which developed with a duplex system after two years' exposure. A further slide was an enlargement of one of the pits, showing the crater-like formation with the more or less concentric rings which corresponded to the laminations in the bright nickel. It was after exposure for two years that this appeared. More work on a

laboratory scale was required to obtain more information about the theory, as this might be very helpful in the problem of providing in practice better protective nickel coatings.

Question of Sulphur

MR. E. A. OLLARD (Atlas Plating Works Ltd.), on the question of sulphur, said that six or seven years ago, when these troubles with bright nickel were first encountered, this point had been raised at an I.M.F. meeting and it had been pointed out that high sulphur was undoubtedly an accelerating agent of corrosion; most of the sulphur-bearing deposits had a high stress in them, and the stress might be a part if not the whole of the trouble. He did not know whether or not that had been sorted out, but in dealing with this subject it should be borne in mind that these deposits, or most of them, were probably more highly stressed. Were any definite figures available? He thought the weight of opinion was that it was due to the sulphur, and he believed that almost all the commercial addition agents were sulphur-bearing compounds, but perhaps someone knew of some that were not, and it would be interesting to hear of them.

In the past too little attention had been given to the actual mechanism of failure. It seemed to him that in the nickel-chrome deposits with which they were dealing a good deal of the trouble came from the action between the chromium coating, which was never, he thought, really continuous—the crack-free deposits were claimed to be, but he still had his doubts—and the nickel underneath. He believed that part of the trouble with the chrome was due to the surface on which it was put. He was concerned primarily with a barrel plant at the moment. Those who were familiar with barrel chroming knew that it was not a very easy operation and had probably found that a good deal depended on the nickel. He had tried a number of proprietary nickel solutions in this connexion and had found that while some of them would barrel chrome quite happily others would not. It was noticeable that the ones which seemed to be the worst on barrel chroming often gave the nicest-looking and brightest nickel deposits. He did not know what was involved; it might be a certain amount of addition agent in the deposit or it might be a film of addition agent coated on the surface, but he believed that with these bright solutions containing addition agents there was some modification in the surface of the nickel which affected the chromium. It would be interesting to hear if anyone had any information or views on that subject.

Mr. Walker's remarks about some of the suggested "sandwiches" were endorsed by Mr. Ollard, who referred to the danger of carry-over

of chromium into the nickel. Most people, he said, used jigs which were protected by organic coatings. It often happened that these organic coatings were inclined to get "tired" at the edges and a little chromium solution got underneath and was extremely difficult to wash out. He was not at all happy about putting some of these processes into commercial operation. He did not want to express any opinion on the labour in plating shops today, but it was desirable for the process to be as fool-proof as possible. A process might work well in the laboratory with skilled operators or chemists, but if used in the plating shop it might be found that the last stage was worse than the first and that it would have been better to keep to what they had been doing before.

He had been interested in the remarks by Jones on zinc-base die-castings, because his own experience, like that of Mr. Jones, had been that there were certain zinc-base die-castings which it was impossible to plate satisfactorily, particularly if they had been stored for a long time in a damp atmosphere. He did not know whether any of the die-castings had been treated in that way, but they contained a little aluminium, and some of those aluminium streaks, which were probably in the surface, were liable to be attacked by water, and especially by some sorts of water. Often those who made the die-castings lacked the space to store them.

B.S.I. Specification

Mr. Such had said that it would be better if the B.S.I. specification were worked to. Mr. Ollard would go further and say that it would be better if people would even read it. His firm had recently been sent brass articles and asked to plate them to N112S, but he could not take brass articles and turn them into steel.

A good deal had been said about the variety of the conditions and of the results obtained, but if something was made to standards which had been laid down it was far more likely to behave satisfactorily under normal conditions of service than if that was not the case.

Importance of Base Metal

DR. D. E. WEIMER, in a written contribution read in his absence, referred to the paper by Brown and Millage, which, he said, showed once again the importance of the base metal in determining the degree of porosity of the electrodeposits. From the electrochemical point of view a copper undercoat was undesirable, but from work with which he had been associated and from that described in the paper it seemed that copper had a useful function in reducing porosity in the composite electrodeposit. However, a pore-free copper-nickel or nickel deposit was not enough to

withstand the rigours of outdoor exposure, and a heavy chromium deposit was essential. The authors pointed out the limitations of crack-free chromium, because of its inability to bridge discontinuities in underlying deposits, but if the nickel-copper or nickel system was of adequate thickness, say an average thickness of 0.0015 in. of nickel, and the components were simple in shape, excellent corrosion resistance could be obtained with an average thickness of 0.03 mil of crack-free chromium, and this was being done in this country extensively. If the nickel deposit was well below these specifications some gross porosity could be expected, and under those conditions a case could be made for duplex chrome because of its ability to reduce the corrosion attack.

In commercial plating it was the areas of minimum thickness which presented the greatest problems, and crack-free chromium served a useful purpose by enabling electroplaters to increase minimum thicknesses without unsightly cracks at the high current density areas, but where the components were of complex shape severe cracking would occur. For these components a further case could be made for duplex chromium because of its exceptional throwing power, which enabled a minimum thickness of 0.03 mil of chromium to be obtained.

Crack-free chromium should be considered as complementary to duplex chromium. There was the question of the price which the user would pay for the improved finish. The results of outdoor corrosion tests carried out in the Detroit area of the United States should not be used as a basis for forecasting the results of outdoor exposure in industrial cities of this country. In the northern parts of the U.S.A. a considerable amount of salt was applied to the roads in winter, giving corrosion conditions not experienced in most cities of the United Kingdom. It would seem, moreover, that great care should be exercised in drawing conclusions from accelerated corrosion tests, because such tests did not always give the same results as test panels.

Corrosion Tests in the U.S.A.

DR. A. KUTZELNIGG (Siemens-Schuckertwerke, Nurnberg), referring to the paper by Brown and Millage, asked a question regarding the corrosion testing procedures used in the U.S.A. There was no doubt, he said, that the most harmful constituent of industrial atmospheres was sulphur dioxide. For that reason, in the United Kingdom and on the continent of Europe testing in sulphur dioxide atmospheres was used and the results were good. It was surprising that in the United States the sulphur dioxide test seemed not to be established at all, and it would be of interest to know the reason for this. No doubt in general the Corrodokote

test gave surprisingly good results, but the authors stated that it was misleading in some cases. Could the omission of sulphur dioxide be the key to the discrepancy? It might be that a combination of Corrodokote and SO_2 testing was the answer.

Vernon had established a long time ago that the tarnishing of nickel was due to the formation of basic sulphate of nickel, the nickel sulphite being unstable. As an intermediate product black NiS was formed occasionally. It was difficult to understand the authors' statement that nickel sulphite was oxidized by the strongly reducing agent sulphur dioxide to the trivalent state, which itself was hardly stable. Further comments on this would be welcome.

A chromium solution with silicofluoride and sulphate as catalysts had been worked out by Gebauer and Solingen even before the second world war.

Dr. S. WERNICK (Consultant, and Hon. Sec. I.M.F.) said that at the present time there appeared to be a somewhat confused situation with regard to the different systems which had been described for the protection of base metal. Certain facts seemed to be emerging, but it would probably be some time before the pattern became quite clear. Brown and Millage stated quite definitely that a thicker chrome, something of the order of 0.1 mil, which was about ten times the normal thickness, would give the best results, but they added that this would tend to blue (or, as one would say in this country, to burn) the edges owing to high current densities, and therefore they advised that the chromium should be reduced to about half this thickness, though such a deposit was very much inferior to the thicker one.

If in fact 0.1 mil of chromium would give so much better results it would be worth making some effort to plate it without burning, and such considerations and attention to rack design and the use of auxiliary anodes or other methods were worth looking at. He felt that it would be worth while diverting a good deal of attention and research away from the nickel-chromium permutations and combinations towards the improvement of the throwing power of chromium in the recesses, and he hoped that some of the resources at Kure Beach and Euston roof would be devoted to this important problem.

Sandwich Deposits

To many people the most intriguing part of the first paper would be that which dealt with the special types of sandwich deposit. Apparently the authors expected to get very considerable improvements as a result of unusual chromium-nickel combinations, but he endorsed Mr. Walker's view that this was going to raise formidable practical difficulties, however good the results might be,

when this was introduced into the shop. To mention a few of them, Mr. Ollard had already referred to the greater risk of chromium contamination of the nickel. Dr. Wernick, having suffered very considerably from a condition where the whole of a shop's output was jeopardized simply through this occasional occurrence of chromium contamination of the nickel, wished to avoid the risk of any further possible chrome contamination as a result of further chrome steps in the process.

There was also the problem of adhesion. It would be necessary to stick the nickel on the chromium. The authors suggested activating solutions or cathodic treatments, and these must add to the series of operations. It would mean vast quantities of additional plant and perhaps big capital expenditure, and the space to house that plant. He fancied that the only people who would welcome the development would be the plant suppliers. In this confused situation he would act in an orthodox manner and prefer duplex nickel + heavier crack-free chromium until further developments had been put forward.

Turning to the second paper, no one was likely to quarrel with the authors' results, which seemed broadly to confirm that thicker coatings of both nickel and chromium increased the protection of the base metal. They also confirmed the American findings in respect of the particular benefit obtained from much thicker than normal chromium. One fact which emerged from everything that had been said was that thicker chromium was very much on the map in these days for helping to give protection.

There was one point on which he must join issue with the authors. They said that casting defects did not affect the protective value of the deposit, and therefore, by implication, the quality of the plating. This was an astonishing and bold statement. Everyone was familiar with the age-old controversy in which the platers blamed the casters and the casters blamed the platers, but in his opinion and experience, and in that of others who dealt with the plating of die-castings, it had been established that co-operation between the casting department and the plating shop was of immense benefit and that good plating had often resulted from eliminating such defects as local porosity of the casting, cold shut or surface laminations. If the authors said otherwise and this was accepted, it would open the way to shoddy castings entering the plating shop with a demand that they be perfectly plated. Having won that battle long ago, platers did not want to fight it all over again now.

Brass Undercoat

Mr. H. J. BACHE (Electro-Chemical Eng. Co.) put a short question to Jones, Carter and Edwards. It was well known, he said, that the usual undercoat

for nickel on these die-castings was copper. In a few cases there was an all-nickel deposit, and in a few more some people preferred to use brass. Would the authors care to express an opinion on the merits and demerits of brass as an undercoat for nickel, when applied in the same thickness as that in which copper would normally be applied?

MR. A. C. BENNING (Harshaw Chemical Co., Ohio), dealing with duplex nickel and its application, said that from some of the comments made and questions raised it might seem that the use of duplex nickel or duplex chromium and heavier chromium deposits was regarded as an open question, but in the United States duplex nickel was accepted as an answer to the many and varied corrosive conditions encountered in that country, and at the present time in the U.S. there were over 1,200,000 gal. of duplex nickel in operation on steel and on die-castings, on steel for about six years and on die-castings for about three years. This extensive use of duplex nickel was due to its having given the results expected in the field, which had correlated with accelerated corrosion tests.

On the question of the differences in corrosive atmospheres and environments between the two countries, it had been said that in England there was not the same use of salt on the streets as there was in the United States and therefore not the same problem in that respect. That was true to a certain extent, but Detroit had been referred to primarily because of its very severe corrosive environment, with salt and fogs and sulphur dioxide in the atmosphere. In the United States, however, there were several types of corrosive atmosphere, including some more severe than in this country and including semi-tropical areas, and their cars stood up to those conditions. Although salt was not used on the roads over here, in view of

the condition of M1 last winter he assumed that salt would have to be used, because even a slight film of ice on M1 would be disastrous.

Duplex Nickel not Experimental in U.S.A.

He emphasized that the use of duplex nickel in the U.S.A. was not experimental, and it had proved a great boon to American platers. Over 350,000 gallons were in use on zinc-base die-castings alone. The American Zinc Institute had held a symposium in Detroit last November. Some of the speakers at the present meeting had spoken there, and it had been more or less accepted that duplex nickel was one of the main answers to the problem of protecting zinc-base die-castings and that the problem now, having protected the base metal from corrosion, was to obtain a measure of corrosion protection of the nickel surface. For that reason a large part of the discussion had been concerned with applying different types of chromium deposit over nickel to protect the nickel surface itself, after two or three years of outdoor exposure, from becoming unpleasant in appearance. The discussion had dealt with the application of heavier chromium deposits, crack-free chromium deposits and duplex chromium deposits on the duplex nickel, and so improving the plating of die-castings.

MR. R. J. BROWN (British Motor Corporation), said that reference had been made to the use of astronomic amounts of salt on the streets of Detroit. Judging by the deliberations in some council chambers in this country, similar amounts of salt seemed to be used here when there was a shower of snow, and it should be borne in mind that British cars were used in the United States, so that the plating produced here had to perform satisfactorily in the streets of America. He did not think that there was much to choose between the

Mr. S. S. Dawson (Sales Director, W. Canning and Co. Ltd.), on the right of the photograph in conversation with Mr. C. H. Sample (centre), of the (International Nickel Co. Inc.). Behind them (left to right) are standing Mr. T. E. Such, Mr. C. E. Proctor and Mr. W. Eckersley (all of W. Canning and Co. Ltd.). Mr. P. A. Cartright, (Manager of the Tyseley Group Laboratories of Wilmot Breeden Ltd.), Mr. H. A. Manning, (Director of Holmes Plating Co. Ltd.), Mr. J. G. Lemon, (W. Canning and Co. Ltd.) and Dr. P. Baeyens (Head of the Electroplating Laboratory, N.V. Philips).



products of British and American factories, judging by the performance of the plated components of American cars in this country. He was constantly being asked by their service people "Why are not our plated components as good as those produced on the Continent and in America?" His reply had been to ask for some samples to prove the point. Generally it was found that British plating was as good as anyone else's, and often better.

The main cause of the failure of plated deposits, as had been emphasized by several speakers, was insufficient deposits, and in particular insufficient undercoats. He did not think that the merits of duplex nickel had as yet been really proved, although the authors of the first paper had provided some evidence of better performance in the field. In the northern part of the United States winter temperatures were somewhat lower than in this country, and, although there was a lot of salt on American roads, possibly the lower temperature would slow down the corrosion rate.

He was interested in the curves shown in the second paper, giving the relationship between thickness of chromium coating and performance. There was an implication in these curves that 0.08 to 0.1 mil was the best for plated material and 0.05 to 0.08 against castings. What was the explanation of the greater optimum chromium requirement for the plated material than for the cast basis metal?

DR. T. P. HOAR (Cambridge University), commenting on Mr. Ollard's reference to the possibility that nickel coatings containing sulphur might be in such a high state of stress that the corrosion rate was greatly increased, agreed with him that the effect was probably a direct one, *i.e.* that the sulphur and not any associated stress was the main cause. Sulphur in a nickel deposit seemed to have two general effects on the rate of anodic dissolution of nickel. For a straight nickel not containing sulphur the anodic polarization was somewhat less in the presence of sulphur, but in particular the tendency of a sulphur-free anode to passivate and become practically non-corrodible at a relatively low current density seemed to go on. These effects were both present in the sulphur-containing bright nickels and probably explained why they corroded at a greater rate than the sulphur-free semi-bright nickels.

AUTHORS' REPLIES

DR. J. EDWARDS, replying to the discussion on the second paper, said that the authors were naturally sensitive about the enormous scatter in some of the graphs in their paper. Most of the work done, particularly in America, on improved methods of plating had, unfortunately, until recently been carried out on flat panels plated with some kind of arrangement to ensure uniform coating. They felt that the most important thing

to do, particularly in connexion with crack-free chromium, was to try out some processes on articles which were somewhat difficult to plate, especially as they had been concerned entirely with die-castings. They had not altogether overcome the difficulties of plating die-castings so as to get a fully bright surface, and this had possibly been due in part to their inadequate technique at the time. They thought that they had now improved their technique and they were continuing the work.

Mr. Walker had been a little inconsistent in criticising both sets of authors for presenting their papers to a conference of platers and not to stylists, who really needed the instruction, and at the same time complaining that the authors of the second paper seemed to give die-casting a clean bill of health. When talking to platers it was as well to concentrate on those things that platers could do something about. Dr. Edwards and his co-authors had no intention of saying that die-castings were easy to plate or that the defects in them did not cause difficulties in plating, but they said that if the plating was acceptable on grounds of appearance of the surface the chances were that it would not fail because of any defects present. They were not really deciding between die-casting and plating defects but rather between the die-caster's responsibility and the plater's responsibility, and that of the man who drew up the specification.

There had been a good deal of previous work done on the question of how far defects in die-castings influenced the performance of the die-casting in service. They themselves had examined several hundred commercially plated die-castings some years ago, recording the position and number of any defects which they could detect, and, looking at them again after a period of a year of use and exposure at the seaside, they could not find that those defects had had any important effect on the deterioration of the coating concerned. They had added to that in the present work by examining the defects and looking at the possibility that the die-cast structure itself would have any effect on performance by taking vacuum die-castings, rolled sheet and gravity die-castings and normal pressure die-castings and finding for comparable thicknesses of nickel and chromium that there were no important differences.

So far as direct nickel was concerned, they had made it clear that they would not wish these results to be used for a reliable comparison between the value of copper undercoat and direct nickel undercoat. They had felt that it was worth presenting the results, however, because they showed the same trend of improved performance up to a thickness of between 0.05 and 0.1 mil of chromium. Where deterioration was more rapid it might be due to some deficiency in adhesion or possibly some

unusual electrochemical relationship between the nickel and zinc, or a different relationship from that with a copper undercoat.

Mr. Such had come to their support in so far as they differed from *Brown and Millage* on the value of crack-free chromium. In an earlier paper which *Millage* with another colleague had given at the A.Z.I. symposium in Detroit last year they had relied largely on a certain number of plated die-cast plates and steel plates which had been exposed in mobile tests. Dr. Edwards believed that the hub-cap results had not at that time been available. Perhaps Mr. Millage would say what had more recently developed on the die-castings in particular, because at the time of the symposium after one year of exposure on cars they had all been perfect whatever the type of coating used, and at that time the authors of that earlier paper had been inclined to say that the reason why the rather thicker crack-free chromium seemed to perform less well than conventional chromium in mobile tests was largely because the corrosive conditions had then been milder, so that in those circumstances the thicker chromium with fewer pores and therefore greater anodic current density in corrosive conditions tended to cause more rapid penetration of the base metal than the thinner chromium, but this was important in mild conditions but not in more severe conditions on the roof. The difficulty with that theory at the time had seemed to him to be that the samples exposed on steel on cars actually behaved worse than any other coating. The emphasis was now placed on the combination of salt on the road and pollution in the atmosphere in producing this adverse effect with rather thicker coatings of chromium. Such conditions might have to be considered even in this country, apart from the question of exporting British products to America.

Chromium on Bright Nickel

Mr. Sample spoke of the adverse effects of chromium plating on bright nickel as opposed to the effect of plating dull nickel and did not think that this could be explained in terms of galvanic effects. It had been generally accepted for a considerable time that a conventional chromium coating on a buffed nickel deposit, whether semi-bright or dull, was likely to have a much larger number of pores than a similar chromium coating on a bright deposit, and therefore in outdoor exposure a larger number of pits developed and penetrated the metal more slowly on the dull nickel than on the bright nickel. That gave a satisfactory explanation entirely in terms of galvanic effect. Mr. Sample and others drew attention to the need for a theoretical study of the mechanism of corrosion by means of potential measurements. It was necessary, however, to

draw attention to the difficulties of this. Many people had made measurements in the simplest possible way, using a simple salt solution or a diluted slurry with simple foils of different metals, measuring sometimes even single cathode potentials against a reference electrode, without any serious attempt to reproduce the conditions so far as the electrolyte was concerned or the geometry of the cells or to simulate the polarization conditions which must obtain. The nearest approach to simulating the geometry of the cell had been made by the Bureau of Standards. In the first instance they had tried having a pool of electrolyte with a chromium foil and immersing the tip of a nickel or iron wire to form the anode, or introducing the nickel or iron wire through a small hole in the chromium foil. They had found that whenever they combined nickel and chromium it was not possible to obtain a steady reading and the potential or current fluctuated wildly. Other workers had found that it was convenient to obtain reproducible results by adding hydrogen peroxide to the sodium chloride solution.

Some work to compare bright and semi-bright or sulphur-containing and sulphur-free coatings from the point of view of duplex nickel had been carried out in a number of electrolytes, and it had shown that the potential relationship between a bright nickel and a semi-bright nickel was reversed if the pH of the solution was raised to the alkaline side. This had to be treated as a very serious research investigation if any conclusions were to be drawn from the result.

On the question of sulphur content, Dr. Edwards agreed with Dr. Hoar that any effect was probably a direct effect and certainly, he would have thought, not an effect of stress, since the stress in many sulphur-containing deposits was not high and was lower than in most dull nickel deposits.

He was interested in what several speakers had said about accelerated corrosion tests. He was surprised to hear a good word said for sulphur dioxide testing, because for a long time he had become accustomed to criticisms of this, most of which were valid. It was useful to consider the limitations of the alternatives. These other tests, he thought, revealed much less about the condition of the chromium than the sulphur dioxide test. In their experience the sulphur dioxide test developed almost the same amount of cracking as exposure to an industrial atmosphere at Euston, but the same amount might not be developed in the milder atmosphere of the seaside.

Mention of industrial atmosphere reminded him that Mr. Walker had said that the conditions on the roof of Euston station were less severe than in the atmosphere of Birmingham or Sheffield. The authors had made comparisons with a very smoky site in Sheffield, and, though a larger amount

of dirt had been collected there, the rate was not much greater. Dr. Edwards remained convinced that on the roof at Euston there was a very vigorous attack on plated articles.

Intermediate Chromium

Several speakers seemed to condemn intermediate chromium outright on the ground of its technical difficulty. He felt that this was not the right approach. Only practical tests would show. *Brown* and *Millage* had outlined a process which gave attention to all the difficulties which might be encountered, and he understood that this process had been operated at least on a pilot scale. The technical difficulties did not appear to be insuperable, but cost was another matter; this process must be more expensive than the alternatives, because it involved, in effect, an addition to the various processes involved in duplex nickel.

As regards the merits of brass as an undercoat, to his knowledge he had never looked at a sample which had a brass undercoat.

Mr. Benning commented on the acceptance which duplex nickel had found in the U.S.A. That could hardly be questioned, but it would be valuable to have evidence that it had been accepted on the ground of improved service performance. Duplex nickel offered the advantages, on steel at any rate, of improved ductility and reduction in polishing costs compared with alternative processes, and it was said even on die-castings to offer certain advantages in reducing the amount of mechanical preparation required and the care with which the copper plating solution required to be controlled, so that there were other advantages in using the process. Further, its advantages were very clear in the Corrodokote and CASS tests, and, since these tests had been laid down by motor manufacturers as acceptance tests, it was in the interest of platers to use systems which the tests themselves required. He would like to see the results of the use of duplex nickel in service put in some form which could be examined.

He was not sure that he understood Mr. Brown's question about the difference in the optimum thickness of chromium on plates and handles. In the series of tests in question the plates as well as the handles were die-castings, and the difference between the two was largely due to the difference in shape, which made "minimum thickness" have a different meaning for the two types of article. There was also a difference between the copper undercoat and the direct nickel undercoat, and that was because of the rather lower thickness of chromium on the direct nickel undercoat.

MR. D. R. MILLAGE, in reply, said that the length of the discussion and the nature of the questions were evidence of the interest taken in the problem of trying to improve corrosion resistance. Mr.

Walker mentioned that flat surfaces seemed sometimes to show rust spots more quickly than recessed surfaces. That could be true in areas where condensation took place, and if a car was left out in the open in the early morning for a few hours when this was happening cells could be set up which would give rise to corrosion on flat surfaces. This might be coupled with the actual thickness of chromium in those areas. It had been experienced in the United States, however, that recesses did fail first.

The economics of thick nickel had been mentioned. Designs today were such that to get the thickness of nickel required in a recess might be very uneconomic. For example, motor car manufacturers in the United States asked for a deposit of 1 mil of nickel in a recess. Other ways of protecting metal might become necessary if that continued.

In reply to Mr. Such, a silico-chloride solution was not preferred for a crack-free chromium because it had been experienced that the porosity was much higher.

He agreed with Dr. Edwards that potential measurements were extremely difficult to make and very difficult to interpret. They had attempted to make some potential measurements and, like the Bureau of Standards, had generally found that chromium became anodic when coupled to nickel, but that did not seem to happen out of doors. They agreed with Dr. Edwards also that the potential relationship between a bright nickel and a semi-bright nickel could be reversed if the pH was raised. What did these potential measurements mean? It was one thing to make a potential measurement on a flat sheet of nickel and quite another to make it on two nickels coupled together. They would like to do this but did not know how to do it.

They were not too concerned about the difficulties involved in running a nickel + chromium + nickel + chromium plant. The only difficulty which could be foreseen was the possibility of drag-out of chromic acid into the next nickel section, but with adequate rinsing and dips, which were relatively cheap, and the fact that a nickel strike would tolerate a good deal of accidental chromium, there should be no trouble. The process had been running on a semi-production scale at General Motors, and there had been no difficulties and the adhesion was good, so that a production plant was now in course of installation to see just what troubles would be encountered.

Undercoats

In reply to Mr. Bache, comparisons had been made between copper, nickel and brass undercoatings for die-castings both in industrial atmospheres and at Kure Beach. In industrial atmospheres copper was very beneficial and the nickel without the copper failed and the brass failed.

At Kure Beach the yellow brass was quite superior.

Mr. Millage then showed a number of slides, which he thought would answer some of the questions put.

He showed a surface view of 0.15 mil nickel and 0.25 mil of chromium after roof exposure for over two years, and also a cross-section of this panel. Also shown was a surface view of 0.15 mil bright nickel and 0.18 mil chromium. When thick chromium was used the deposits were never totally porosity-free; there were always some pores through the chromium into the nickel. If they could plate on completely pore-free chromium and crack-free chromium the results would be outstanding, but that situation was not obtained. A further slide showed a panel with a good many large surface pits and another a typical cross-section of one of those large pits. The rate of penetration through the nickel and into the steel had been greatly accelerated. It was evident that the corrosive action was truly galvanic and it was a cathodic-anodic area relationship, although that was not the whole story.

The question of sulphur in a nickel deposit had been raised, and Dr. Edwards had covered the ground very well. A slide showed a surface view of a nickel foil 10 mils thick with 0.01 mil of chrome after three years on the roof. The surface was covered with small, hardly visible pits. Another slide showed a cross-section through the nickel foil. They had taken some of this nickel foil and instead of chromium plating it on the dull side plated it on the bright side; it was still sulphur-free nickel. Subsequent slides showed the surface (on which the pits were few and scattered) and a cross-section. At least in an industrial atmosphere the sulphur had little bearing.

Dr. Hoar had shown that bright nickel and free nickel were relatively similar at the lower current densities. It was conceivable that in their own case the current densities were at the point where the polarization would be the same.

On another slide a bright nickel and chromium sample which had been on the roof for three years was shown. It had a number of little blue surface pits, the size of which depended on the thickness of the nickel. In this case, being only 0.2 mil, they grew quite large, but small blue dots on the slide were actually underlying the layer of chromium; the next slide showed a cross-section of the chromium layer. Such panels after five years had corrosion pits with the chromium still showing, but the pits were at least $\frac{1}{8}$ in. in diameter. It was probable that eventually all the bottom layer of chromium would be showing.

The fact that the anode-cathode relationship might not be the whole answer was shown in the next slide, where the two panels were essentially the same and had been put on the roof at the same

time; one was a complete mass of rust and the other had only a few rust spots. The only difference between the two was that the one wholly rusted had been cathodically sulphuric acid treated after chromium plating. The two panels had been on the roof for only two months.

In answer to Mr. Ollard, the next slide showed that the type of nickel on which the chromium was put might have an influence on corrosion. The panels illustrated showed the state of 1 mil thickness of bright nickel with 0.01 of chromium after 2, 3 and 5 months of exposure on the roof, and the next slide showed exactly the same bright nickel, formed in exactly the same fashion, but cathodically treated to remove a surface film of some kind. The difference was amazing.

The final slide showed results presented at the A.Z.I. symposium in 1959. The zinc die-cast panels had been returned this year looking exactly as they did the year before. They had a good many small depressions—they had been mounted on the front bumper of a car—but they came back looking very good. Some of the steel panels remained the same but others had deteriorated.

ABSTRACT No. 3

SEALING ANODIC OXIDE FILMS ON ALUMINIUM

by G. C. Wood.*

THIS paper sets out to investigate the marked chemical and physical changes that take place when sealing the strongly adherent oxide films formed on aluminium when anodizing. Although the exact process is rather uncertain, it is generally understood that the anion in the electrolyte migrates to the anode forming aluminium oxide with a reduction in free energy. More recent research has indicated that the moving ions are cations, the anions only being mobile in the sense that their lattice moves as a whole.

Work has been directed towards determining the dimensions of thin barrier layers and the thicker outer layers in acid electrolytes. It was found that although the metal reacts electrochemically, the net film growth rate is less than the theoretical value and falls with time. The concept of coating ratio, the weight of the coating divided by the total weight of aluminium reacting, was suggested after work with sulphuric acid as the anodizing agent, and it was found that the higher the temperature and concentration the lower the coating rate.

A method was developed of estimating the thickness of the barrier layer by making a specimen anodic in a borate solution and determining the voltage at which there was a sharp rise in current.

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It was found that the forming voltage, current density, and time, control the amount of barrier layer formed, whereas the thickness/ v is determined by the electrolyte and its concentration and temperature.

Early optical and electron microscope studies showed that porous anodic films closely resemble the ideal columnar mixture of Wiener, in that they consist of a system of cylindrical pores situated in a medium possessing a higher refractive index than the pores, and the bi-refringence of the layers was demonstrated experimentally. It was later shown that the difference in colour could be explained by the variation in film thickness from grain to grain.

The surface of the metal showed an approximately hexagonal pore-base structure, each hexagon corresponding to one pore. Recent work has shown that they are not uniform, craters in the metal corresponding to domes at the film/electrolyte interface. The pore diameter is dependent on the anodizing electrolyte, being greatest for the phosphoric and least for the sulphuric. It was found that the equation $S = 2W E + P$, holds where S is the cell size, W is the wall thickness in A.U./ v ., and E is the forming voltage and P the pore diameter.

The results of nitrogen adsorption experiments suggests that there are irregularities in the pore sides which are beyond the power of the electron microscope. Other studies showed that the pores have the shape of truncated cones, their diameter increasing with the distance from the barrier layer, but this has not been confirmed.

The anodic films themselves may be amorphous or contain γ - Al_2O_3 or both. It is also likely that films formed on mechanically abraded or polished metal tend to be amorphous and those formed on electropolished metal tend to be crystalline, because of epitaxy effects at the metal/film interface.

It has been postulated that, after the initial formation of the barrier layer, the pores begin to nucleate by autocatalytic local thinning at certain points at the oxide-electrolyte interface, directly above weak sections in the film. Fresh barrier layers are formed at the base of the pores, but the pore sides, not carrying appreciable current, are only slowly attacked.

A number of workers have investigated the electrical properties of anodic oxide layers and the work has indicated that relatively clear physical and electrical models have been provided. It is also evident that it is possible, by choosing the correct anodizing variables, to keep an accurate quantitative control over such factors as total film thickness, barrier layer thickness and pore diameter and distribution.

Although no detailed examinations were carried out, it was shown that the initial series resistance

and capacitance of a sealed anodic film were respectively considerably higher and lower than the values for unsealed layers, and that the hydrated oxide does not interfere with the measurement of barrier layer thickness.

The resistance of anodized and sealed aluminium is critically dependent on the metal purity, since impurities and alloying elements such as copper tend to make the oxide film less protective.

Simple corrosion tests showed that sealing improved the corrosion resistance, and a comparison in the loss of weight after exposure to a rotating salt solution, found that sulphuric acid formed coatings, sealed in potassium dichromate solution, lost six times as much weight as films sealed in water.

For certain purposes exposure tests have proved more reliable than accelerated tests and considerable detail about the choice of site, materials and other conditions are given in this paper.

It was also demonstrated that sealed films have lower abrasion resistance than unsealed layers, the values for coatings sealed in dichromate being less than those sealed in hot water. The value does not appear to be constant throughout the film, but is related to the degree of hydration, decreasing rapidly at first but eventually slowing to a small amount.

In conclusion, the paper says that the change in properties of anodic films appears to be associated with the movement of ions in the layer after anodizing, together with the largely physical adsorption and absorption of water. On heating in hot water or steam, the changes are much more radical, partial or complete hydration of the film to give bohmite, occurring accompanied by large reduction in porosity.

In the case of sealing in other electrolytes, hydration is probably accompanied by other processes, with nickel acetate the deposition of nickel hydroxide formed by hydrolysis and with sodium silicate the formation of aluminium silicate. When dichromate /chromate mixtures are employed, the inhibitive action of the ions and their reaction with the walls to give aluminium oxydichromate or oxychromate must also be considered.

ABSTRACT NO. 4

ON THE ASSESSMENT OF SEALING OF ANODIC OXIDE FILMS ON ALUMINIUM

by T. P. Hoar* and G. C. Wood*

A COLORIMETRIC method of estimating the degree of sealing of anodic films on aluminium is described. The general aim of the work was to examine the influence of sealing on the absorption

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of dyes, coloured chemicals on easily estimated chemicals qualitatively and quantitatively so as to develop a method of following the rate and extent of the sealing process and to compare the results with those obtained by other methods, in addition to devising a simple test for adequate sealing, capable of industrial use.

After exploratory experiments six specimens of 99.99 per cent aluminium were degreased, chemically polished, washed in distilled water and anodized (H_2SO_4) to give films 15×10^{-4} cm. thick. They were then sealed in distilled water at 95°C . for a range of times from 0 to 1440 minutes, re-washed and post sealed in potassium dichromate solution for 10 min. at 95°C . A similar run was carried out with nickel acetate solution as the sealing agent.

The quantity of Cr picked up on post-sealing was determined quantitatively using diphenylcarbazine with a Spekker photoelectric-absorbtiometer. For this the film was dissolved in NaOH, the solution was then acidified with H_2SO_4 and the diphenylcarbazine colour measured. The determination is not affected by the presence of aluminium but nickel is said to interfere; the films sealed in nickel acetate have not yet been investigated.

In other experiments, anodized, sealed and post-sealed films were dipped directly into solutions containing diphenylcarbazine and H_2SO_4 for various times. After washing, they were examined visually for any evidence of reaction between the diphenylcarbazine and the Cr in the film.

The experiments showed that the longer the sealing time the less dichromate was picked up during the post-sealing treatment. The chromium uptake may be expected to be proportional to the available alumina area, i.e. the area of the walls of the partially unsealed pores and hence to the pore

radius, and chromium uptake is a sensitive measure of sealing.

The results also show that the absorption of dyes and coloured chemicals is not solely dependent on pore size. Assuming that it is small enough to enter a pore, a molecule or ion to be absorbed must be able to adsorb on a pore wall, and its ability to do so depends on the electrical condition of the material forming the wall. Dipping the anodic film in the sealing bath probably alters the zeta-potential at the oxide/solution interface; the adsorption of ions in the double layer would lead to a reduction or reversal of the zeta-potential, so altering the adsorption of the dye or coloured chemical species. With dichromate $\text{Cr}_2\text{O}_7^{2-}$ or CrO_4^{2-} ions may also be built into the pore sides during the simultaneous hydration process.

Chromate post-sealing appears, therefore, to be a useful method of estimating the rate and extent of sealing, and results are in general agreement with those obtainable by impedance measurements.

A practical test for the extent of sealing could well be based on chromate post-sealing. By water sealing, an unsealed or poorly sealed film acquires a visible yellow colour, whereas a commercially sealed film does not.

The chromium uptake is easily determined quantitatively by diphenylcarbazine and the method could readily be adapted for the routine checking of the extent of sealing. It would also be very suitable for the control of sealing techniques should more complete sealing than is now commercially usual come to be required. The method of determination suggested, i.e. colorimetry, is simpler and quicker than weight gain.

However, diestuff tests do not indicate whether an alumina film is properly sealed or not but only whether the sample has been in a sealing bath for a few moments or not.

Relaxing in the famous Cricketer's Room of the Grand Hotel after the morning technical session are (left to right): Mr. G. Dance (R. Cruickshank Ltd.), Professor J. W. Cuthbertson (Dept. of Metallurgy, Nottingham University); Mr. A. J. L. Nash (Managing Director, R. Cruickshank, Ltd.), Mr. R. A. F. Hammond (Head of the Electrodeposition Branch, A.R.D. E.), Mr. A. W. Wallbank (Managing Director, Ionic Plating Co. Ltd.), Mr. A. A. B. Harvey (Director Technical Services, Sunbeam Anti-Corrosives Ltd. and president of the Institute), and Mrs. J. W. Cuthbertson.



DISCUSSION

MR. J. C. BAILEY (Aluminium Development Association) said that those interested in the further development and improvement of anodic films in general practice would welcome wholeheartedly Dr. Wood's review of the mechanism of both anodizing and sealing. It came at a very opportune moment, because in practice an attempt was being made to use anodic films in circumstances which were quite new, such as exterior exposure on buildings, in car trim and for other purposes and wanted to get the best performance which could possibly be obtained. In that procedure of stretching the films, metaphorically, to its limits he wanted to know why they fell short, when they did fall short, and how they could go further.

There was another field of application for anodic films which should be borne in mind in the discussion, and that was the use of anodic films, usually continuously applied, for electrical insulation, for which there was a large potential demand as operating temperatures of windings of various electrical apparatus steadily rose. From the point of view of development, therefore, it was very important to study films which had failed for one reason or another and to apply such knowledge as Dr. Wood's review revealed to put the matter right.

Dr. Wood had presented a very able and thorough review of complicated data, with a total of 140 references, and was or had been himself engaged in practical research on anodic films. It was all the more disturbing, therefore, to find the sort of conclusions which he reached. Having reviewed the sum total of human knowledge on the sealing of anodic films, he came to the conclusion that not very much was known about even the basic facts of the mechanism of sealing, despite the fact that the process had been in use for the last thirty years. That was a sad state of affairs and emphasized the need, to which Dr. Wood himself had referred, for continuing if possible more intensively the study of sealing processes which would pave the way to the development in practice of more precise sealing techniques. That procedure had in fact already begun, and some of the suggestions made in the paper had already been adopted by practical anodizers to obtain a better product than they had been putting out even two or three years ago.

Sealing with Molybdate

Reading the paper, having in mind the possibilities for immediate improvement in processes which it revealed, he had been struck by several points. He was particularly interested to see that molybdate was recommended as a sealing agent, and he wondered whether Spooner, who had done the work referred to in the paper, had given any information on whether in fact molybdate sealing led to improved corrosion resistance of the film.

Mr. Bailey deplored the departure from scientific precision in the use of the word *Duralumin* for a material. *Duralumin* was a word very loosely used for aluminium alloys. It did not refer to the familiar, traditional Al-Cu-Mg alloy, age-hardening, but to a whole series of materials of vastly different characteristics and properties, so that its use in such a paper did not give readers the information which they required.

Turning to the paper by Hoar and Wood, it was very good to see new suggestions being made for a sealing test and in particular the possibility which was being opened up of a quantitative assessment of the degree to which a film had or had not been sealed. There were other tests which had been put forward in the last few years, involving largely sulphur dioxide, but he did not think that they claimed to be able to give any quantitative view of the situation, and if that could be achieved it would be a very great step forward. It seemed to him, looking at the tests available at the moment for sealing, that the almost traditional ASTM test could now finally be discounted as being no guide at all to the efficiency of sealing. He hoped that the BSI would bear that in mind when revising their standard. At the moment the current edition of the standard did not venture on any sealing test. He hoped it would be possible for that to be remedied when next a revision was undertaken.

With regard to the test itself, the authors admitted that more work was needed to try the test out in different circumstances with different films formed in different electrolytes and so on. He urged that the work should be carried on so that it culminated in a test which was well tried out in all circumstances and provided a much-needed means of assessing the sealing of anodic films in practice.

Testing Films after Long Service

In that connexion, could the authors offer any comments at this stage on whether or not the test could be applied to films which had been in service for some time? From the practical point of view it was necessary to be able to test a film not only immediately after it had been sealed but after, for instance, it had failed in service and it was desired to check the efficiency of sealing. Would the test be suitable for a film which had been out of doors for a year or so?

Finally, could the authors or any one else give any practical data on the effect of longer sealing times on corrosion resistance? Did they in fact lead to improved performance? Academically, one could think of reasons against that happening, as well as those that Dr. Hoar had suggested for it happening.

Washing Anodized Films

MR. J. M. SPRAGUE (Consultant Electrochemist) said that in recent years a good deal had been heard

Reflecting the general spirit of good-fellowship which characterized the Conference, Mr. F. D. Tubbs, (left) (Sales and Joint General Manager of the Hockley Chemical Co. Ltd.) enjoys a passing jest with his colleague Mr. M. S. Gosse (Technical and Joint General Manager).



about the need for very thorough washing of the anodized film before the sealing was undertaken, and in some quarters it had been recommended that the time of washing should approximately equal the time of actual anodizing. He noted, however, that Hoar and Wood anodized for 19 min. and washed for 1 min. He would have expected the course of the subsequent processes which they discussed to be very much influenced by the amount of sulphuric acid and other materials retained in the pores of the film and would therefore like to know the authors' reasons for the use of a washing time of only 1 min., and what were their views on the employment of a longer period.

In presenting his paper Dr. Wood showed a picture of a model of the film in which the pores were shown as vertical cylindrical holes. Mr. Sprague had the impression that as a result of some part of the film which had been anodized having been for a longer period in contact with the solution and its dissolving action, the diameter of the pore varied from one end to the other. It might be that the representation was intended to be purely diagrammatic and it was not right to argue about what the electron microscope showed; but, if it was accepted that there was this variation in diameter, it might have an important bearing on some of the measurements made, such as those which had been illustrated by Dr. Hoar. What importance did the authors attach to this?

MR. A. W. BRACE (Aluminium Laboratories Ltd.) suggested that it was first necessary to ask,

more from the point of view of the practical anodizer and the user, why an interest was taken in sealing. He further suggested that the criterion of good sealing could be whether the sealing treatment resulted in an adequate retention of the original appearance of the article over its life. It was quite possible to have a definite deterioration in the appearance of an anodized article even when exposed indoors in a relatively mild atmosphere, as for example handrails in an office building. The results of bad sealing could be seen even under such mild conditions.

Second, it was of importance for the retention of colour in the dye. Anodizing was used on many domestic utensils and appliances and the housewife, the user, did not want to see the article losing its colour. Such a phenomenon had been known to happen.

Last, he suggested that the function of sealing was to impart the maximum possible corrosion resistance to the coating. There it must be asked how much of this was a function of sealing and how much it was a function of the thickness of the anodic coating and of the material on which it was put.

Having asked those questions, it was of interest to consider the authors' contributions and to see in what direction progress was being made. If more was known about what happened in sealing it should give a better understanding of how to preserve it and how to improve it. A question not dealt with in the paper, but which was of

theoretical interest and might have practical implications, was whether or not the pores of the coating were actually closed by sealing. His colleague Mr. Spooner had made some calculations based on indirect data which indicated that probably the pores of the coating were never actually closed. If that were so it might modify the picture of the way in which anodic film resisted breakdown when exposed to the weather.

Another question was why the corrosion resistance of a sealed anodic coating was dependent on the temperature of sealing. It was probably reasonable, as Dr. Wood suggested, to believe that at low temperature bayerite was probably the result of leaving the coating in warm water and bayerite was almost always associated with pits in corroded aluminium, and that indicated its poor protective properties. When the temperature went up to the region of 75-80°C. bohmite was formed, but it was significant that the characteristics of bohmite formed at 80°C. were vastly different from those of bohmite formed at 120°C. in superheated water or superheated steam. He would like the authors to comment on why that was so. He was inclined to suggest that it meant that bohmite had an imperfect structure at low temperature which did not normally complete itself unless there was more driving force behind the mechanism, which the increased temperature gave.

Optimum pH of Sealing Bath

It was all too common to find in practice that the pH of the sealing bath did not always achieve the optimum of 5.5-5.6 which was frequently quoted in the textbooks. Sulphuric acid could be carried over to the sealing tank, and, as had already been pointed out, there were differences between what could be done in the laboratory and the precautions which it might be necessary to take in practice, when there were crevices and corners and other places which were awkward to get at.

After very long times of sealing the anodic coating there was still a change in the electrical properties taking place and the indications were that in fact the process had not stopped, but it was not necessary, and could be detrimental to the appearance of the anodic coating, to seal it for too long. About 10 min. seemed sufficient to achieve most of the corrosion resistance, and 30 min. certainly, while after an hour the appearance would be worse than if the sealing was not carried on for so long.

He thought that diphenylcarbazine was an unfortunate choice to refer to specifically, as it could give a good deal of trouble in bloom deposit not only on the pores of the coating but on the surface and could be difficult to remove. Also, the sulphur dioxide-sodium sulphite test was better than the dichromate test in that it brought out the effect of calcium and magnesium in ordinary

mains water, which the dichromate test did not do. The dichromate test showed up the differences between films sealed for long periods and not for ordinary commercial purposes.

MR. J. M. KAPE (Alumilite and Alzak, Ltd.) said that the whole of the method which the authors used for the assessment of the sealing of anodic films depended on the reaction of dichromate ions or chromate ions with the surface layers of pre-sealed anodic films. Did the authors consider that the amount of dichromate picked up in a pre-sealed anodic film was actually a measure of the amount of sealing (*i.e.*, the amount of pore filling which had occurred) or was it only a measure of the change of surface electrical properties which might occur as the time of pre-sealing increased? In other words, was it fair to suppose, as a result of this work that the normal anodizing practice of sealing for 20-30 min. in boiling water gave an insufficient degree of sealing? There was a good deal of discussion in the literature concerning the amount of sealing expressed as a percentage filling of pores relative to the time of sealing. Did the authors consider that the increase of corrosion resistance of an anodic film presumably obtained by the three-hour sealing treatment was warranted, particularly in so far as the potential difference of anodized aluminium measured over a period of time fluctuated over much the same range of values whether the film was sealed for 2 or 30 minutes?

He was particularly interested in the work which was being carried out on the influence of film thickness relative to the chromate test. The majority of commercial anodizing done in this country had a film thickness of between 3 and 10 microns, and even free sealing gave only a very weak colour with such a coating, which tended to limit the applicability of the method in workshop practice. Most anodic films in this country were sealed in mains water, and it had been found that the type of water and the conditions under which it was used greatly influenced the efficiency of the sealing operation.

Since Dr. Wood submitted his paper to the Institute some work had been carried out in this country, giving a brief evaluation of the various methods of coating which could be used and which should not be used and an assessment of the various techniques by the use of a sulphur dioxide solution. The solution contained sodium sulphite, 10 gm. per l. and acetic acid. The specimens were immersed in the solution for 10 to 30 min. at a temperature of 90 to 95°C. They were examined afterwards for the amount of chalking or bloom, the amount of which was proportional to the original amount of sealing and could be assessed visually or gravimetrically. The badly sealed specimens lost a great deal of weight in the test solution as the unsealed film was soluble in the solution, and the

test could detect incorrectly sealed work and discriminate between various mains waters.

With reference to Dr. Wood's paper, the sealing of anodic films and the adsorption of various dyes and pigments into them depended very largely on the sizes and charges of the anions or cations or molecules which were being adsorbed, and the adsorption was dependent on the electrical effect of a double layer formed by the film on the one part and the electrolyte—water, metal acetate, or inorganic or charged organic salt—on the other. Adsorption would occur if the sizes of the ions which had to enter the pores were favourable and the equipotential at the surface was a suitable value. Very little sealing occurred in water at pH 4 where the pH was adjusted to that value by certain acids; it all depended on the acid used to obtain that pH figure, and an anodic film would adsorb chromate or dichromate which would not adsorb permanganate or sulphite at the same pH.

AUTHORS' REPLIES

DR. T. P. HOAR (University of Cambridge), in reply, said that the sulphur dioxide test was much nearer to a corrosion test than to a test of porosity. He felt that for testing porosity *qua* porosity and nothing else some test was required which would give information about the area within the pores which was still available for chemical reaction, because the actual mechanism of sealing must be the chemical reaction of the sides of the pores with the electrolyte which got into the pores. The best way to know whether that had ceased was to find some other chemical reaction which could be studied quantitatively to see how much of the pore sides was left, so as to assess the extent to which the pores had not been sealed. That was why the authors had adopted the chromate method as giving a reasonable illustration of the degree of sealing that needed to be done, largely because chromate could be used for the whole of the sealing. A bright orange colour was obtained if the film was sufficient in the first place.

He agreed with Mr. Bailey that tests of many kinds of anodized material were required, sealed in many different ways, if any kind of test was to be put on a proper basis. It would be interesting to see whether or not it was possible to utilize the test for material which had been exposed to the atmosphere. He was inclined to think not, because there might then be corrosion products formed of a highly flocculent type, in which case there would be a tremendous uptake of chromate.

Mr. Sprague asked whether the pores were really cylindrical holes. The electron microscope pictures were particularly satisfying in this case and the pores appeared to be very nearly cylindrical and not larger at the top than at the bottom. One reason might be that although it was conventionally

said that the film was soluble in the electrolyte it was in fact soluble only in very specialized conditions. It was doubtful whether the Al_2O_3 dissolved in sulphuric-acid anodizing electrolyte unless it was under the influence of a high field at the bottom of the pore. He believed the solution to be akin to an electrode process and to be assisted by the great drop of potential over a very short distance between the bulk of the film and the bottom of the pore and the electrolyte immediately outside it, and that the dissolution did not occur down the sides of the pore. The reasons which might be adduced for this were many, but the main one was that if an anodized film was left not in contact with the metal, particularly in sulphuric acid, it did not lose weight at anything like the rate that it did during the anodizing process itself.

What are Closed Pores ?

The answer to Mr. Brace's question of whether or not the pores were closed by sealing depended on what was meant by "closed." The authors pointed out that commercial sealing times closed the pores, according to their estimate, by something of the order of 90 per cent of their cross-sectional area. The authors believed that the results given, coupled with others which they would publish shortly on the resistance of the electrolyte in the pores, showed that commercial sealing gave something like 90 per cent closure and no more. Whether or not that was enough was another matter, but probably in most cases it was.

Mr. Brace also asked why bayerite was more protective than bohmite, and there Dr. Hoar did not know that anyone had a good answer. There seemed to be little doubt, however, that bohmite formed at high temperatures tended to be better than that formed at rather lower temperatures. It might well be that there was a more complete transformation of the lattice and a more complete hydration of the Al_2O_3 simply because the reaction went faster.

Mr. Kape asked whether or not the uptake of chromate was a true indication of the pore area decrease. The authors thought that it was, for this reason. When, by a.c. impedance methods, the electrical resistance of the pores was measured, it was found that in most cases as the sealing proceeded the pore resistance increased in a nearly linear manner with time; it was also found that there was roughly a rectilinear relationship between $1/(\text{pore sectional area})$ and sealing time and thus between pore resistance and sealing time. The fact that both these things gave a roughly linear time relationship made him think that their pore area as estimated from chromate adsorption was indeed the true cross-sectional area of the pore.

(Continued in page 199)

Deposition of Tungsten for High-Temperature Service

VAPOUR-DEPOSITION PROCESS DEVELOPED IN U.S.A.

THE U.S. National Bureau of Standards has recently developed for the U.S. Navy an entirely new vapour-deposition process by means of which high-purity tungsten can be plated on metal surfaces. The new method, devised by W. E. Reid and Dr. A. Brenner of the Bureau's electrodeposition group, involves reducing gaseous tungsten hexafluoride with hydrogen by passing it over the heated object to be plated. At temperatures above 300°C. tungsten is deposited on the hot surface, and the only other reaction product, hydrogen fluoride, passes out with the excess hydrogen.

By this method, it is possible to coat numerous simple and complex surfaces such as rocket and missile nozzles and jet-engine parts. The new technique also lends itself to the fabrication of tungsten articles, and may be the only way that complicated shapes of tungsten can be formed. Simple tungsten shapes for use in vacuum tubes have already been fabricated.

Tungsten is one of the few metals that possess structural strength at temperatures above 2000°C. Its extremely high melting point (3140°C.) hardness, and corrosion resistance make it a desirable material for high-temperature equipment. However, until recently, the high-temperature properties of tungsten could not be effectively utilized. Its brittleness and hardness prevented it from being machined by conventional methods while its weight restricted its uses in aeronautical equipment. For these reasons, efforts were made to develop a practical method for depositing tungsten coatings.

Because tungsten deposition has not been accomplished from either aqueous or organic solutions, it was necessary to evaluate deposition from both fused electrolytes and gaseous phase. However, in the fused electrolyte processes, the rate of plating was too slow, the deposit was too tough, and coatings could not be built up to the desired thickness.

Tungsten hexafluoride was selected for use in the vapour deposition process for two reasons. First, the compound is a gas at room temperatures and therefore convenient to use. Second, tungsten apparently forms only one compound with fluorine — WF_6 . Thus the reactions are straightforward, without too many by-products or side reactions.

The equipment required is simple. The article to be plated is placed inside a cylinder of ceramic material and the air pumped out and replaced by hydrogen. A controlled temperature induction furnace heats the article to about 650°C. Then the two gases, tungsten hexafluoride and hydrogen, are passed through ordinary glass flowmeters into the reaction chamber. When the gaseous mixture comes in contact with the heated article, tungsten is deposited on the hot surface. The by-product

(continued in facing page)



Fig. 1.—W. E. Reid, one of the developers of the new technique, inspects equipment used for the vapour-deposition process at the U.S. National Bureau of Standards.



Fig. 2.—The illustration shows articles plated by the new process and are a rocket nozzle (right bottom), cross section of a rocket nozzle (centre bottom), small sample rectangular pieces (3rd centre row); also articles fabricated entirely of tungsten are shown. Components for an electron furnace (left and centre top), thick tungsten rocket nozzle insert (right top), sample tubing (2nd from left centre and left top), and a crucible (right centre)

Electrolytic Deposition of Tungsten for High-Temperature Service.

(continued from previous page)

of this reaction, hydrogen fluoride, is absorbed in a suitable trap.

Although the theoretical ratio of 3 mols. of hydrogen to one mol. of hexafluoride is needed for complete reduction, satisfactory coatings are obtained when the ratio is lower. However, in practice, smooth deposits are insured by using a hydrogen-to-hexafluoride ratio greater than 6. Wide variations in the flow rate of the gases and in the pressure in the systems have no major effects on either the efficiency of the process or on the quality of the coating. Although the optimum temperature range for rapid formation of smooth deposits is 650 to 700°C. temperatures in the range from 300 to nearly 900°C. are fairly effective. Definite crystal growth is observed at 900°C. when the ratio of hydrogen to hexafluoride is 3 to 4.

Spectrochemical examination shows that the tungsten obtained by vapour deposition is purer than ordinary commercial tungsten. Silicon is the only impurity present in a concentration of 0.1 per cent or more. Also the deposited metal has the theoretical density of pure tungsten—19.3 gm. per cu. cm.—which is higher than that of tungsten compacts produced by powder metallurgy, or by flame spraying. This means that plating eliminates the very small holes between tungsten particles resulting from the other two processes. The hardness of the deposits contained at 650°C. is about 475 VHN or about the hardness of ordinary commercial tungsten. The crystals deposited at 900°C. are not as hard (410 VHN), indicating a

slightly higher degree of purity.

The adhesive bond between the tungsten coating and various basic materials was investigated. Adhesion to molybdenum and to nickel was good; to copper, somewhat weaker; and to iron, rather poor. The tungsten-graphite bond was about as strong as the graphite itself. Tungsten deposited on ceramics also showed good bonding.

Deposits 1/16 inch thick were obtained by vapour deposition in an hour. In this same time only 0.001 inch thickness of tungsten could be plated from fused salts melts in electrodeposition. The maximum thickness of deposit that can be obtained by the vapour method has not been determined, but would depend on the permissible roughness of the surface. Because of the rapidity of deposition, this process lends itself to the continuous production of tungsten-coated strips or wires.

Plating a metal strip or wire is simple, but the uniform distribution of tungsten over an irregularly shaped object is a problem that must be solved for each item. Deposition is more uniform over the exterior of an object if plating is conducted in a chamber much larger than the object. Since tungsten deposition occurs in greatest quantity where the gases first strike the hot object, better distribution probably can be obtained by passing hydrogen through the main opening in the chamber and leading the WF_6 to various parts of the object, by a system of injector tubes.

For obtaining a desired tungsten shape without the other metal underneath, the metal form is chemically dissolved after deposition. The method of separating the tungsten depends upon the other metal used.

Oil and Colour Chemists' Association

O.C.C.A. Exhibition

This is the second and concluding instalment of a description of the exhibition held during March by the Oil and Colour Chemists Association. The first instalment appeared in last month's issue of this journal.

Farbenfabriken Bayer Aktiengesellschaft *Leverkusen Bayerwerk.*

For several decades the comprehensive production programme of Farbenfabriken Bayer Aktiengesellschaft has included Alkydal (alkyd resin) and the range of types is steadily being supplemented by new products in order to meet the ever-increasing requirements of industry and the consumer.

In addition to the dehydrated castor-oil types, Alkydal R 35 has been developed, which is a short-oil dehydrated castor-oil type with improved viscosity stability without reduction of surface hardness and possessing very good pigment binding properties in addition to the good adhesion, flexibility and colour retention properties, characteristic of the dehydrated castor-oil-based types. It yields the desired high-gloss film of great body in stoving finishes as well as in forced drying finishes (80°C) which are of particular interest today.

For stoving finishes and for nitro-cellulose combination finishes, Alkydal E 26 (arachis-oil modified) and Alkydal C 25 (coconut-oil modified) have recently been added to the range. The stoving finishes produced from these two products are free from light and dark yellowing and in connection with melamine or urea formaldehyde resins they show remarkable viscosity stability. Alkydal C 25 has the specific cool white shade required of coconut alkyds, but as regards adhesion, it is claimed to surpass the coconut level so far generally accepted. In nitro-cellulose wood polishing and machine buffing lacquers, they are both distinguished by their resistance to oil and petrol (gasoline); also, they are insensitive to buffing wax, so that even on dark wood perfectly non-blushing films of deep lustre can be achieved.

In addition to the well-known applications of polyurethane coatings from Desmodur and Desmophen, further new and interesting applications have been found. The Desmodur L available for the production of Desmodur/Desmophen coatings is virtually free from volatile isocyanates

(TDI), so that processing will have no physiologic effect on the operator. It is available as a 67 per cent solution in ethyl glycol acetate/xylene, 1:1, with a flash point higher than 30°C. so that both polyurethane coatings of a higher flash point, as well as favourable formulations for application by brushing can be produced.

The unsaturated polyester resins for the coating industry, which are marketed under the trademark of Roskydal and which can be processed with or without paraffin wax addition, were also shown. As they cure in any desired thickness of layer, which can be applied on one operation, they have given excellent results as wood polishing finishing and also as kitchen furniture finishes and automotive repair fillers and surfacers. As an item of particular interest, a single-coat finish on metal was shown which is resistant to corrosion and abrasion and which is distinguished by high body.

The Geigy Co. Ltd.

Rhodes, Middleton, Manchester.

The Geigy Co. Ltd. made a special feature of their plastisizer, Reomol RIG, at the exhibition, pointing out that in general, paint makers first consider the use of plastic material in organosols where the solvent facilitates application by normal painting methods, but stressed the advantages to be gained from the use of plastisols, which contain no solvent and where the pigment and polymer, usually pvc, are dispersed in a plasticizer. Recent development work at the Geigy laboratories has shown the vital role of Reomol RIG in producing spraying consistency.

It gives a plastisol which is low in viscosity and can, therefore, be sprayed, but at the same time gives good paste viscosity stability and produces tough flexible films, and a paste prepared on these lines was available for examination on the stand. Work carried out so far indicates that pigmented plastisols can readily be produced, and several panels illustrating the variety of effects in both colour and texture, were on show.



Fig. 1.—The Geigy Co. Ltd., featured Reomol RIG.

The company is also active in the field of chemicals for metal cleaning and electroplating, and a number of the products developed and introduced often find application in fields which are not directly related. One of these is Benzotriazole, which is a corrosion and tarnish inhibitor for copper and its alloys, and was on show on the stand. It forms a protective layer on the metal surface and prevents dissolution, thus also often protecting the solution itself against the effect of dissolved copper. It can thus find use in certain applications where contact with copper gives rise to staining, or where machinery or equipment containing copper components are in use.

Goodyear Tyre and Rubber Co. (Gt. Britain) Ltd.

Wolverhampton

This year's exhibition saw the formal introduction, in this country, of Goodyear's Pliolite S-5 bases and Pliolite resins for traffic strips. The bases, developed for easier incorporation into paints, are available in resin-pigmented mixtures. Designated Pliolite S-5, they are soluble, in aromatic solvents and a number of interesting properties are claimed, one of which is its chemical resistance. Coatings based on this, make it possible to paint most types of masonry surface without fear of paint failure, even by alkali attack. They offer protection to floors as well as structural steel, machinery and plant where chemical corrosion presents a problem. Speciality uses include those of marine, traffic stripe paints, and aluminium- or zinc-rich sprayable coatings.

Fig. 2.—(right) Pliolite bases and resins were shown by the Goodyear Tyre and Rubber Co.

Goodyear have also developed a special resin for use in solvating with white spirits or any combination of solvents having a KB value of over 40. This resin is Pliolite VT and is used extensively for road traffic markings, and reflective stripes. The company claim the following outstanding qualities for this resin:

- (a) resistance to the effects of vehicle traffic and weather;
- (b) excellent bead resistance;
- (c) quick-drying time plus ease of application;
- (d) may be used on bituminous surfaces where low solvency power is required;
- (e) resistance to oil and chemicals.

Exposure panels of coatings based on Pliolite S-5 exposed under normal British conditions for varying lengths of time, in addition to panels demonstrating the colour range available through the use of these bases, were on show at the company's stand. They were ably supported by the evidence of static and photographic exhibits of installations in this country and elsewhere, showing applications of Pliolite-based paints in traffic stripes.

Hygrotherm Engineering Ltd.

5 Fitzhardinge Street, Portman Square, London, W.1.

A considerable portion of the company's research programme is concerned with the development of chemical engineering techniques which can be applied in the manufacture of raw materials for the surface coating and plastic industries, especially synthetic resins, polyesters and plasticizers.

Their stand this year was mainly concerned with advances that have been made in the field of mains-frequency induction heating, applied to stainless clad steel reaction vessels and also to glass-lined steel reaction vessels. References were made to the test facilities which are provided by the company and which are of particular value to overseas manufacturers.



Improvements have also been affected in the company's range of indirect heating systems employing hydrocarbon oils, diphenyl/ diphenyl oxide and organo-silicate liquids as heat transfer media, but definite technical information was difficult to obtain.

Imperial Chemical Industries Ltd.

Imperial Chemical House, Millbank, London, S.W.1

I.C.I. was represented at the exhibition by four Divisions—Dyestuffs, Nobel, Heavy Organic Chemicals and General Chemicals. The Dyestuffs division had as its theme, "I.C.I. Pigments and Resins for Industrial Finishes." Three new pigments, "Monolite" Maroon GS, "Monolite" Fast Yellow FRS and "Chromastral" Red RS, were shown for the first time. "Monolite" Maroon GS and "Monolite" Fast Yellow FRS are specially suitable for use in car finishes, industrial lacquers and enamels, while "Chromastral" Red GS is primarily designed for general purpose industrial finishes. Two new "Bedacryl" resins, 7s and 8w, were also on show for the first time, together with an exhibit relating to new developments in acrylic emulsion paints.

Nobel division featured silicone resins for heat-resistant paints and silicone primers and topcoats for emulsions and cement paints. White and coloured paints based on silicones will resist temperatures of 250°C. for long periods, while silicone aluminium paints have excellent resistance up to 600°C. and good weathering properties. Also on show was trimethylol propane, a tri-hydric alcohol used for preparing short-oil alkyd resins for stoving enamels, and neo-pentyl glycol, a di-hydric alcohol for preparing esters and polyester resins and plasticizers.

Included among the products displayed by Heavy Organic Chemicals Division were propylene glycol, dipropylene glycol, dimethylterephthalate, cumylphenol, trimellitic anhydride and "Thermex." Propylene glycol is used in the manufacture of certain polyester resins, which are being increasingly used in the production of low pressure laminates and also in surface coatings, dough mouldings and cements. Dipropylene glycol is also used in polyester resins, while resins made from dimethylterephthalate are suitable for the manufacture of surface coatings.

Cumylphenol, now made for the first time in Britain by I.C.I., is an excellent intermediate for the manufacture of phenolic surface coatings, possessing exceptional chemical resistance. Trimellitic anhydride, a highly reactive new raw material, is of special interest for the manufacture of water soluble and oil soluble alkyd resins. "Thermex," the first heat-transfer medium of



Fig. 3.—The four divisions of the I.C.I. stand.

its type to be made commercially in Britain, is suitable for use in a wide variety of plant for the manufacture and processing of synthetic resins, paints and varnishes.

The General Chemicals Division featured in their display a model of the "Alloprene" unit. Test panels showed the performance of paints based on this medium under a variety of outdoor weathering and accelerated tests. It is claimed outstanding among paint resins for its resistance to chemical attack and paints based on it are widely used for the protection of buildings, steelwork and chemical plant against corrosive atmospheres.

Johnson, Matthey and Co. Ltd.

73-83 Hatton Garden, London, E.C.1.

This year Johnson Matthey featured, in addition to cadmium yellow and red colours, a new yellow pigment which will be marketed under the name of Matthey titanate yellow and was shown in stoving lacquer, in thermoplastics and in other media.

Claimed to be highly resistant to heat, light, moisture and chemical reagents, it has exceptional opacity and is a pleasing lemon colour in full shade. It is stable in dispersions in titanium dioxide, and is therefore of particular value where very pale yellow and cream colours are required. It is well known that cadmium lemons when widely extended with titanium dioxide to produce pale tints suffer colour loss in certain conditions, and it is hoped that this yellow pigment will effectively fill the gap in the inorganic range.

A series of colour blends based upon Matthey pigments were also exhibited in plaques of polystyrene and other plastics.

Imperial Smelting Corporation Ltd.

37 Dover Street, London, W.1.

The Corporation featured their range of barium pigments and extenders.

Zinc sulphide pigments, with improved exterior durability, were shown as development products and their properties illustrated by means of electron-micrographs and exposure test panels. Some effects of changes in the pigmentation level of zinc sulphide pigments on paint behaviour were demonstrated, particularly with respect to hiding powder.

Pigment-extender mixtures can show large variations in packing of the particles and the effects of changes in the proportions of pigment and extenders in three-component mixtures on oil absorptions were shown by means of solid models. Uses of zinc tetroxychromate and zinc dust in priming paints for metals and other substrates were also demonstrated.

Laporte Titanium Ltd.

14 Hanover Square, London, W.1

Laporte Titanium Ltd. introduced this year two new materials, titanium nickel yellow, a new yellow pigment and tiona TD, a treated anatase titanium oxide.

Titanium nickel yellow is a combination of nickel oxide and titanium dioxide brought about by calcining at high temperatures. It is an extremely stable medium yellow pigment of comparatively high opacity. Because of its nature and the manner of its preparation, titanium nickel yellow is very inert and consequently is stable to heat, light and chemicals, both acids and alkalis. It is also insoluble in solvents and therefore can be regarded as non-bleeding and because of its properties titanium nickel yellow can be used where heat resistance, chemical resistance and resistance to fading are required. The crystal form of the pigment is similar to that of rutile titanium oxide and, up to the present time, tests indicate that this pigment has a high degree of chalk resistance and light stability.

It was made clear that the pigment is not a mixture of titanium dioxide and yellow pigment. Each particle in the pigment is yellow and consequently when used alone, no pigment separation difficulties arise. The yellow titanium oxide may be reduced with titanium oxide to give even paler shades. These reduced shades maintain the light stability of the original titanium nickel yellow. It is not as fine as the treated grades of titanium oxides, e.g. Runa RH20, but has a soft texture and no difficulty should be experienced in dispersing this pigment in most media by conventional milling methods.



Fig. 4.—Titanium nickel yellow, exhibited by Laporte Titanium Ltd.

Tiona TD is an after-treated anatase titanium oxide, which has relatively easy dispersing properties and a resistance to after-yellowing which is markedly superior to the normal anatase titanium oxide. Its main application will be found in stoving finishes, printing inks and pigmentation of plastic materials.

The Research Association of British Paint, Colour and Varnish Manufacturers,
Paint Research Station, Waldegrave Road,
Teddington, Middlesex.

A number of standard pieces of apparatus are used for recording general meteorological information and for measuring the amount and character of atmospheric impurities. Many of these instruments are in regular use at the Paint Research Station, and in addition, certain instruments have been specially designed and were on show at the exhibition. Among them was apparatus designed to measure the surface wetness of paint films and the intensity of ultra-violet light from the sky.

Many important forms of atmospheric pollution can be measured by means of a deposit gauge which collects both insoluble and dissolved substances in rain water. The solid matter, consisting of organic tarry matter, metallic compounds and other inorganic dusts, are responsible for soiling paint surfaces and the development of stains. The soluble metallic compounds are mostly in the form of chlorides and sulphates and analytical records have been made over a number of years at the Research Station of material collected in deposit gauges at Teddington and Manchester.

The results of these, and associated studies were illustrated, together with examples of some paint defects, such as bloom, yellowing and stains, which can be related to atmospheric impurities.

Research Equipment (London) Ltd.

64 Wellington Road, Hampton Hill, Middlesex.

A wide range of testing equipment was shown and included humidity, salt-spray and sulphur-dioxide cabinets, apparatus for the measurement of scratch resistance, fire retardance and abrasion resistance.

The humidity cabinet primarily for corrosion testing, consists of a copper-lined container incorporating a water tank at one end which is heated by an electrical immersion element. The temperature is raised from 42°C. to 48°C. over a period of thirty minutes and the heater automatically cut off and the temperature allowed to fall again over a period of thirty minutes, during which heavy condensation takes place on the test-pieces, fitted in trays inside the cabinet. Air is circulated by a fan which can be controlled in speed from the control panel.

The unit covers the Chemical Inspectorate (Ministry of Supply) Specification DEF.1053 Method 25, and more severe tests can be carried out by adjusting the heat input. Many and varied modifications can be incorporated, one of which is a stainless-steel lining for sulphur-dioxide testing. The manufacturers say that these cabinets can be practically tailor-made for any specification and quote as an example their use in testing plastics for mould growth.

Shell Chemical Co. Ltd.

Marlborough House, 15/17 Gt. Marlborough Street, London, W.1

The stand of the Shell Chemical Co. Ltd. had two major sections, one for solvents, the other for "Epikote" epoxy resins, and they illustrated the characteristics of these products and their applications in the surface coatings industry.

The solvents exhibit featured a recently-introduced range of high boiling hydrocarbons with a wide choice of volatility and of the high quality associated with petroleum-derived products. The general properties of these solvents, known as the "Shellsol" range, have already been published but new information on them, relating particularly to their chemical constitution and electrical properties has become available as a result of recent laboratory work. Also the end use pattern of the range which showed its versatility, was displayed. The products in this series are "Shellsol" A, E, N and X, all aromatic products, and "Shellsol" T, which is aliphatic in nature.

Three new developments concerning "Epikote" resins were on show, and were: solventless coatings, fluidized bed powders and "Epikote" resin/isocyanate systems. Solventless coatings based on the resins reduce application costs as they give the required film thickness in one coat. Fluidized

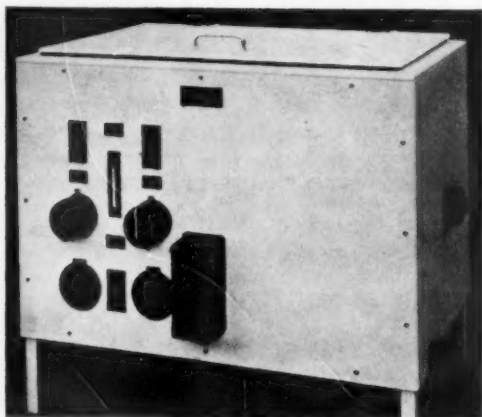


Fig. 5.—Copper-lined humidity cabinet from Research Equipment Ltd.

bed powders consist of finely divided "Epikote" resin, pigment and curing agent which when suspended in a current of air will adhere to a heated article placed in the powder cloud. On withdrawing the article a film is obtained which can then be cured by further heating. This method has been developed for applying coatings to awkwardly shaped articles. "Epikote" resin/isocyanate systems show properties differing in certain respects from those obtained with amine cured systems and applications where these properties can be used to advantage, were illustrated.

Literature and information was available on many other Shell chemicals for the industry including propylene glycol, used in the manufacture of polyester resins.

Fig. 6.—Shell placed particular emphasis on 'Epikote' and 'Shellsol.'



Spelthorne Metals Ltd.

Batchworth Wharf, Rickmansworth, Herts.

Spelthorne Metals Ltd. this year adopted as their theme, the use of metallic lead pigment for marine applications, and showed a large number of test panels illustrating the versatility of metallic lead paints, where marine and chemical attack is prevalent.

Due to the very fine particle size, an average of one micron or one twenty thousandth of an inch of the lead paste, the product of this company has been called "atomized lead." Finely divided metallic lead is an inhibitive pigment which has been used for many years as a constituent of protective paints for ferrous metals, and suitably formulated metallic lead paints give excellent protection against corrosion. Even where rust appears on a fractured surface, there is no creep under the paint film, and it can be used satisfactorily in the formulation of protective dipping paints.

The use of metallic lead paints covers a very wide field, and is a worthwhile constituent of priming paints for galvanized surfaces and for the repair of partially galvanized iron.

Although metallic lead paints are relative newcomers to the marine world, their use in this field has been highly successful, and ships of all types are now being protected, both above and below the water line, with this type of paint.

Steel and Cowlshaw Ltd.

Cooper Street, Hanley, Staffs.

The company featured on their stand the new Steel-Shaw Super Rapid Disperser, on view for the first time at an exhibition. This model has been designed to meet the increased demand for machines to give improved products in considerably less time than by conventional methods, and has many applications in the field of dispersion and solution of solids in liquids, especially where finely divided solids are required to be rapidly dispersed in viscous solutions of resins, varnishes, lacquers and numerous other coating materials. It combines the advantages of high power with a high-speed impeller and can deal with moveable capacities of from 25 to 150 gallons. The impellor can be easily cleaned when changing from one colour to another. Another interesting feature of this disperser is the variable-speed control which enables correct speeds to be selected to suit individual dispersions. Fig. 7 illustrates this new piece of equipment.

Also on view was the Mark 1, high-speed ball mill, a small capacity mill designed for either laboratory work or production work where relatively small quantities are required. It is capable of processing materials of low or high specific gravity

and is offered as a 1-h.p. or 3-h.p. machine depending on the weight per c.c. of material to be processed. Fitted with four interchangeable pots, which can be supplied in stainless steel, mild steel or hard porcelain, materials of different kinds can be processed simultaneously.

All the mills manufactured by the company, operate on the same principle of planetary motion. The pots are arranged on the periphery of a circle and revolve at high speed around a central drive, setting up a powerful centrifugal force which holds the grinding media and charge against the wall of each pot. Each pot is geared to revolve in the

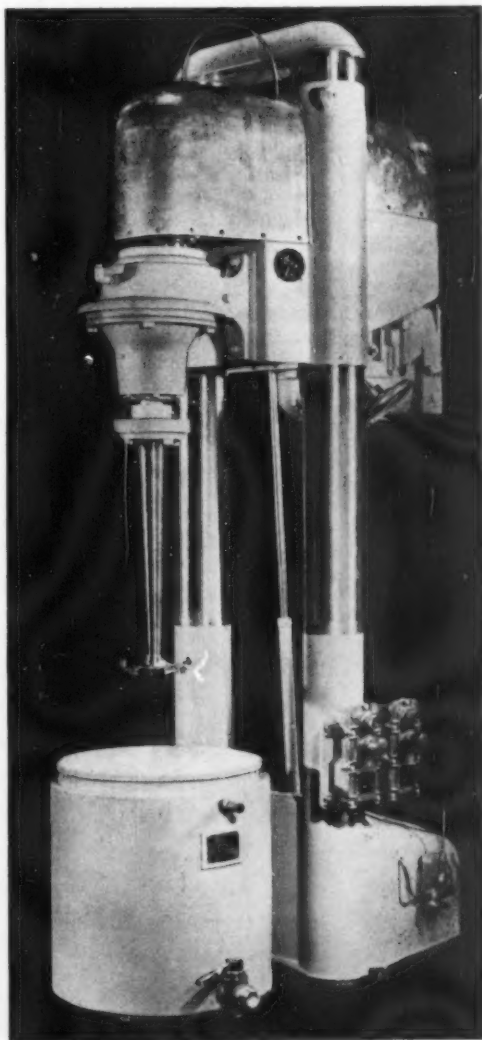


Fig. 7. (right) The Steel-Shaw Super Rapid Disperser.

opposite direction on its own axis, causing activation within the mass of grinding media and charge.

A microprojector was shown as an example of the type of equipment used by the company to carry out tests and trials for clients in their laboratory, and dispersed systems can be studied up to a magnification of 2300.

The Tin Research Institute

Fraser Road, Perivale, Greenford, Middlesex.

The Tin Research Institute featured by demonstration, the use of dibutyltin compounds as stabilizers for chlorinated rubber paints and of tributyltin as fungicides, boicides and as anti-fouling agents.

They pointed out that manufacturing variations sometimes yield chlorinated rubbers unstable to light, with a consequent discolouration and decline in protective quality of the paints produced from them. Addition of 0.01 per cent. of dibutyltin dilaurate to the paint assures stability and permits the use of low-viscosity grades of chlorinated rubber to produce paints of improved performance.

The tributyltin compounds are claimed to be remarkably toxic to fungi and moulds. By incorporating small amounts in paints, the growth of these organisms on painted surfaces can be prevented and photographs of panels used in anti-fouling trials were shown to illustrate the effec-

tiveness of tributyltin abietate against marine growths, two of which are shown in Fig. 8. They are plates treated and untreated with organotin anti-fouling compounds, after immersion in the warm sea at Shoreham harbour.

Union Carbide Ltd., Chemicals Division

103 Mount Street, London, W.1.

One of the main features concerned the Company's new plant at Hythe which is coming on stream during the first quarter of this year. This plant will convert ethylene into ethylene oxide by direct oxidation, and thence into a range of derivatives including mono-, di- and tri-ethylene glycols, "Carbowax" polyethylene glycols, ethanolamines, "Cellosolve" and "Carbitol" glycol ethers and "Tergitol" monionic surface active agents; many of these products being of considerable interest to the surface-coating industry. The annual production of these ethylene oxide derivatives will be initially of the order of 45,000,000 lbs.

On the main walls of the stand, was featured the use of the Company's chemicals in the various sectors of the surface-coating industry.

Thickeners and Stabilizers: "Cellosize" hydroxyethyl cellulose, available in a range of viscosity grades, recommended for thickening aqueous systems, especially resin emulsions, and noted for stability against ionic materials. Solutions are of exceptional clarity and show good temperature stability.

Solvents: "Cellosolve" and "Carbitol" glycol ethers and ether-esters as high boiling solvents for cellulose lacquers, impart excellent blush resistance and solvent tolerance. "Cellosolve" acetate is particularly applicable in conjunction with epoxy and acrylate resins. "Carbitol" acetate assists film coalescence in latex paints.

Resin Intermediates: Intermediates for a range of synthetic resins include epichlor-

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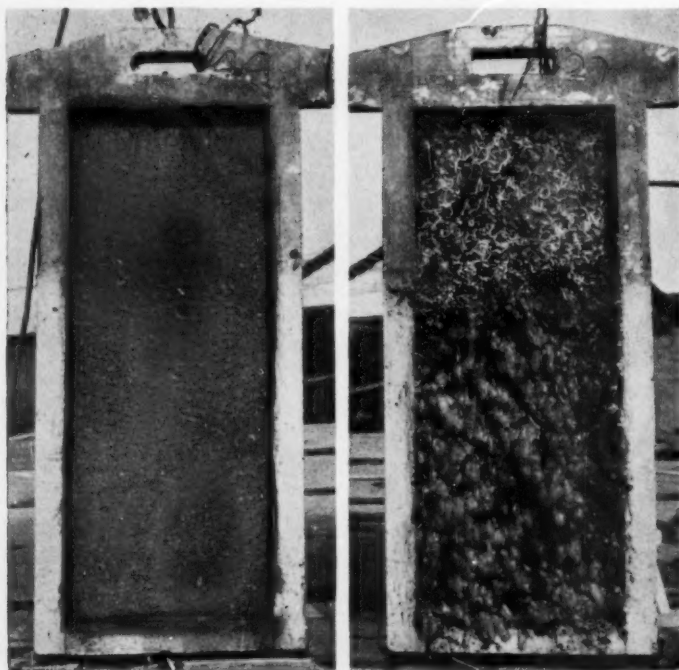


Fig. 8.—Two plates, treated (left) and untreated (right) with organotin anti-fouling compound, after immersion in Shoreham harbour.

O.C.C.A. Exhibition

(Continued from page 198)

hydric and polyamines for epoxy resins, glycols for alkyd and polyester resins, "Niax" polyethers for polyurethane resins. Also polyamines, such as ethylene diamine, for polyamide resins for use in thixotropic finishes.

Monomers: Acrylates, in particular 2-ethylhexyl acrylate, copolymerised with vinyl acetate for use in latex paints to give enhanced durability and flexibility. Ethyl acrylate and acrylic acid form acrylate polymers for automotive finishes.

Surface Active Agents: "Tergitol" alkyl phenol ethylene oxide condensates for stabilising latex dispersions, and dispersing pigments for use in latex paints. Also "Nonex" nonionic agents and "Gemex" cationic agents for pigment dispersions.

Organic acids, C₆-C₁₀, in particular 2-ethyl hexoic acid, have been recently developed for use in paint driers. This acid forms heavy metal soaps of improved solubility in drying oil formulations. Iso-decanoic acid, 2-methylpentanoic acid and 2-ethylhexoic acid are recommended for blending in alkyd resins for specialised applications.

Another recent addition to the company's products is a new polyol, 1 : 2 : 6-hexanetriol, which reacts with dibasic acids to make alkyd resins, claimed to form softer and more distensible film than alkyds based glycerol.

I.M.F. Conference

(Continued from page 189)

He was not surprised to find that potential fluctuations were much the same for thin, thick, sealed and unsealed specimens. Very little reliance could be placed on the measurement of the electro-potential of aluminium in any circumstances, because the metal was so reactive that one never measured a true potential of any kind. Small defects in the film would give wild fluctuations of the potential.

DR. G. C. WOOD, in reply, apologized in reply to Mr. Bailey for the omission to give the exact composition of the Duralumin alloy. Those interested would find it in the paper by *Whitby* which was referred to. So far as molybdate was concerned, he believed that *Spooner* had done some experiments and had simply stated that he thought it might be a useful new sealing electrolyte. There had not been much further work done on it.

He would add one small comment on the use of the authors' proposed test for films which had been in use for long periods. Dr. Hoar had referred to

the possible presence of corrosion products, but there was also the possibility that the film might have aged, because the dichromate would have been adsorbed to a certain extent into the oxide film, and this might contribute as well.

Standard Washing Time

In reply to Mr. Sprague, the standard washing time of 1 min., which was purely arbitrary, had been chosen because they wanted to avoid any ageing effects. Dr. Wood had not done any tests with different washing times, but impedance measurements showed an increase in the resistance of the oxide film for anodic films washed for one hour in distilled water which was identical within the limits of the method with that of films washed for one minute, so that they had felt justified in using the minimum time.

As Dr. Hoar had said, the electron microscope seemed to show that the pores were fairly uniform. Dr. Wood believed that for higher temperatures and higher concentrations of acid there was some evidence that right at the opening there was some opening up. There was also a paper by *Cosgrove*, using gas adsorption methods, in which it was stated that the pores had the shape of truncated cones, but this had not been confirmed by the electron microscope. There was also evidence that the actual size of the pores was not absolutely uniform. There were probably micro-cracks leading in from the sides of the pores.

In reply to Mr. Brace, it was important to consider the differences in corrosion resistance of bayerite and bohmite formed at different temperatures. The authors had investigated the temperature-dependence of sealing in their impedance measurements, and the dependence on temperature seemed to depend quite critically on the nature of the sealing electrolyte. For example, in potassium dichromate solution, with a pH of 3.7, sealing seemed to be relatively independent of temperature between 65° and 95°C., but with the higher pH of about 6.7 in nickel acetate solution there was a very critical dependence on temperature and below 90°C. the sealing rate as measured by electrical resistance was very much lower.

So far as the pH of the sealing was concerned, it should be emphasized that it was the actual pH of the electrolyte in the pores which was important. This could be decided to a certain extent by the pH of the bulk electrolyte, but also, particularly in the case of water, by any dissolution products of sulphuric acid left in the pores. The reason for using nickel acetate was that it was a highly buffered electrolyte when used with boric acid and the results were very reproducible. He thought that the effects of smudge were over-estimated, and in the authors' work he had found that it had virtually no effect.



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NEWS REVIEW

HARD CHROME PROCESS FOR SURFACE HARDENING, CORROSION AND ABRASION RESISTANCE

HOLMAN Brothers Ltd., Camborne, Cornwall, announce the enlargement and re-equipping of its Durion hard chrome deposition plant to meet demands from within the Holman Group and from other companies. This development, which follows the opening of the new Holman Heat Treatment Department, places the Group in an advanced position in metal treatment and finishing. The Climax Durion Plant, as it is called, handles all chrome processing work for the Holman Group and holds under licence the exclusive agency for this process in the West of England.

Climax Durion hard chrome is chiefly used to provide a wearing surface of great hardness and durability for all types of metal with the exception of aluminium. It possesses an extremely low co-efficient of friction, has high corrosion and abrasion resistance and can be used to salvage components that are undersized, chipped or have damaged edges, by rebuilding and restoring to original specifications. The Durion process is also used as an alternative to surface hardening by heat treatment and has an additional advantage in that parts can be re-treated when the chrome has worn away. It prevents pick-up and seizure between stainless-steel and non-ferrous components and can take a highly polished mirror finish.

A significant development, and one with considerable possibilities for economy, is the increasing number of components — previously made from stainless steel — now being machined from mild steel and subsequently hard-chromed by the Durion process. Hard-chrome deposition has unlimited applications in such fields as general engineering, the mining, aircraft, motor, plastics and printing industries, in the manufacture of screens, in food and drink processing, and pumping.

The Climax Durion hard chrome process involves basically the electro-deposition of hard chrome direct on to ferrous or non-ferrous materials. The extent to which a component is treated can be accurately controlled and any portion of the component which does not require plating can be isolated by means of a wax coating.

The chrome is deposited electro-

lytically, requires no intermediate deposit of material and is bonded intermolecularly with the base metal.

The thickness of the hard chrome deposit can be varied from 0.00005 in. to more than 0.10 in. and in exceptional cases, particularly in the salvage of stainless-steel parts, 0.20

in. has been deposited. The rate of deposition depends on the size and shape of the components, but an average figure would be a rate of approximately 0.001 in. per hour.

When components are submitted for hard chroming a technical inspection and examination is carried out and all dimensions are recorded. The components are, if specified, also pre-process stress-relieved by low-temperature oil and then assembled for processing and jigged-up on mild-steel jigs to which electrical contacts of copper are attached. The components are immersed in vats containing chromic acid and other chemicals used only in Durion solutions which are maintained at controlled temperatures and agitated by compressed air. The current used to achieve electrolytic deposition is of a very high amperage and extremely low voltage. When the correct amount of chrome has been de-

(Continued in page 202)

THE components shown below were once badly worn but have been reclaimed by the Durion hard chrome deposition process to a thickness of 0.020 in. at the Durion Department of the Climax Rock Drill and Engineering Ltd., Camborne, Cornwall, a member of the Holman Group.



Hard Chrome Process

(Continued from page 201)

posited the components are removed from the vats, finally checked for quality, size and thickness of deposit, etc. and after certain essential finishing processes, are oiled, packed and prepared for despatch.

The Climax-Durion plant works in close co-operation with Durion Ltd., Bracknell, and also with other licensees of the process in Holland, Northern Ireland and South Africa. The combined experience of these companies, the exchange of information regarding new production methods and unusual or new applications will ensure that the Durion process keeps in the forefront of hard chrome practice.

EUROPEAN FEDERATION OF CORROSION ENGINEERS

THE British Association of Corrosion Engineers has been elected a member of the European Federation of Corrosion. The object of the Federation, which is a non-profit making union, is to promote European co-operation in the field of research on corrosion and methods of combating it for the benefit of the community at large. Membership of the Federation is restricted to non-profit-making European technical and scientific societies whose activities are connected with the field of corrosion or the protection of materials.

The Federation seeks to achieve its objects by convening joint European meetings for the discussion of subjects of general interest, by convening meetings of working parties for the discussion of specific problems, by the creation of working groups for investigating special problems, by the organisation of study trips, and by other means. The General Secretariat of the Federation is managed jointly by the DECHEMA in Frankfurt a.M. and the Société de Chimie Industrielle in Paris.

The British Association of Corrosion Engineers was formed last year generally to promote the dissemination of technical information about corrosion matters, to develop the free interchange of information among members, and to promote such educational and other facilities as may be required for the establishment of corrosion engineering as a recognized profession. Individual membership (two guineas a year) is open to everyone interested and associated with corrosion engineering. The address of the Hon. Secretary is 97, Old Brompton Road, London, S.W.7.

BRIGHT PLATINUM PLATING

Improved Solution claims Quicker and More Stable Deposits

THE development of platinum plating has been limited due to the difficulties associated with conventional plating baths. Johnson Matthey have now made available a stable platinum plating solution from which bright, heavy and coherent deposits may be obtained. This bath, known as DNS Platinum Plating Solution, is based on the complex sulphato-dinitrito-platinous acid, $H_2Pt(NO_2)_2SO_4$, and patent applications covering electrolytes of this type have been filed in a number of countries.

The bath is acidic, and may therefore be used successfully on electrical components and on printed circuits. Platinum from DNS solution can be deposited directly on to copper, brass, silver, nickel, aluminium and titanium. For deposition on tin, zinc, cadmium or steel an undercoat of silver or nickel is necessary.

The high resistance to corrosion characteristic of platinum, coupled with its ease of deposition, assure the electrodepositor of a wide variety of industrial uses.

Deposits from the new bath are said to be exceptionally bright and lustrous at all thicknesses, and no polishing is required. Electrographic tests have shown no evidence of porosity in deposits up to 0.001 inch in thickness on polished copper. Above this thickness some slight evidence of cracking may be observed. Microhardness tests on deposits give values of 400 to 450 VPN.

The DNS Platinum Plating Solution is supplied as a concentrate containing 10 gm. platinum per 100 ml. of solution. For general use this should be diluted to 5gm. platinum per litre. Glass, earthenware or plastic tanks should be used.

The character of the deposits remains unchanged in the temperature range 30 to 70°C, but the recommended operating temperature is 50°C.

At a current density of 5 amp. per sq. ft., and at 50°C, the deposition rate is 0.0001 inch in two hours. At this rate very accurate control can be exercised over the amount of metal deposited, and for the majority of applications these conditions represent the best compromise of efficiency with economy.

A faster rate of deposition can readily be achieved by using a solution containing 15 gm. platinum per litre at 20 amp. per sq. ft., again at 50°C. In these conditions a thickness of 0.0001 inch will be deposited in 30 minutes.

No agitation is required in using the bath.

Where necessary, plating can be confined to specified areas by masking with a chlorinated rubber paint.

Insoluble anodes are used in the process, and these should be of platinum. The anode surface area is not critical.

This new platinum bath gives bright, smooth deposits over a wide range of operating conditions. Deposits may readily be obtained up to 0.001 inch in thickness, and the bath gives consistent and reliable performance. The range of conditions within which satisfactory plates can be obtained makes the bath easy to work, and it does not deteriorate on standing.

NATIONAL ENGINEERING LABORATORY—OPEN DAY

THE National Engineering Laboratory is to hold Open Days on Wednesday and Thursday, June 15 and 16, 1960, when the laboratory will be open for inspection. Special displays have been arranged including many items developed since the last Open Days in 1958. Facilities for sponsored investigations for industry will be on show, as well as results of work carried out as part of NEL's general programme of basic and applied research. These include the automatic measurement of errors in machine tools, the development of hydrostatic transmissions, research on the cold extrusion of steel, studies of the performance of high-speed bearings, investigations of the growth of fatigue cracks, and the preparation of new international steam tables.

Representatives of any organization with engineering interests will be welcome. Applications for invitations, stating which day is preferred, should be sent to:

The Director,
National Engineering Laboratory,
EAST KILBRIDE, Glasgow.

WESTINGHOUSE SECURE CONTRACTS FOR NEW TINNING LINES

THE Westinghouse Brake and Signal Co. have secured the rectifier contracts for two more high-speed tinning lines requiring a total of 430,000 amp. of direct current, following the successful operation of their equipment at the Velindre Works of the Steel Company of Wales, where-direct-water cooled selenium rectifiers provide a total of 450,000 amp. on three continuous electroplating lines, and a later installation at Cornigliano Spa at Genoa providing 110,000 amp.

The first of the new contracts is for Richard Thomas and Baldwins Ltd. at Ebbw Vale where the Head Wrightson Machine Co. Ltd. are the main contractors for the whole plant. The electrical equipment includes 220,000 amp. of water-cooled germanium rectifiers, together with the transformer stepping down from the 11-kV systems, transducers to control the plating current and automatic controls to provide plating current exactly proportioned to the speed of the line, which can run up to 1500 ft. per min., enabling the thickness of the tinplate to be accurately controlled.

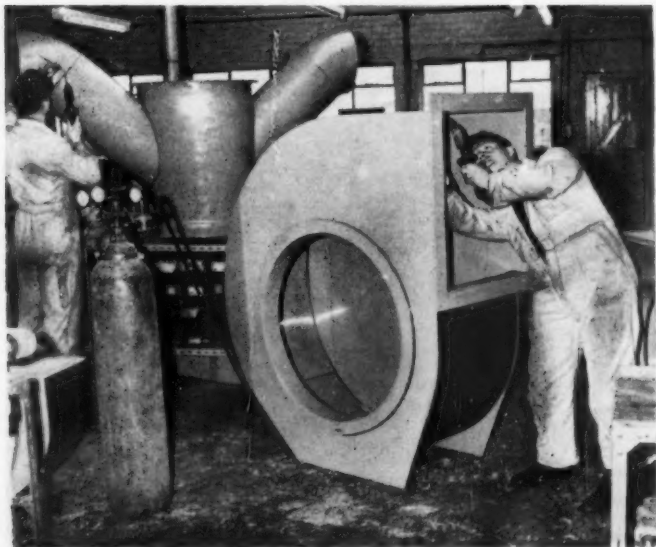
The second contract is for a 2000-ft. per min. tinning line at the Port

Kembla Works of the Australian Iron and Steel Ltd.; this line will require 330,000 amp. ultimately but only 210,000 amp. in the initial stages. Silicon has been selected as the best rectifier to meet the temperature prevailing, the rectifiers being air cooled in a recirculating system where the heat is absorbed by sea-water heat exchangers.

The silicon diodes, transformer and transducers and control system are being made at the Chippenham Works of the Westinghouse Brake and Signal Co. Ltd. who are supplying this equipment to their Australian Subsidiary, McKenzie and Holland Pty. Ltd. who are building the rest of the equipment.

PLASTIC CENTRIFUGAL FANS

THE illustration below shows engineers assembling a 33-in. diameter inlet fan at the Plastic Fan Co.'s works. This company specializes in centrifugal fans, fume extraction plant and automatic barrelling units and considers that because it is unaffected by corrosion the use of polyvinyl chloride for the construction of industrial fans provides an answer to the problem where noxious fumes constitute a danger to plant efficiency and employees' safety.



Uses of Stelvetite Continue to Expand

STELVETITE, the plastic-coated sheet steel manufactured by John Summers and Sons Ltd., of Shotton, Chester, is now being used extensively by Herman Smith Mastercraft Ltd., for a new range of hearth furniture.

The new Mastercraft range consists of three coal, or log, boxes with all visible surfaces covered with seal-embossed Stelvetite and with a choice of polished brass or chromium-plated fittings and ornaments. These are available in red, black or grey, except the largest of them which is in black only.

Existing Mastercraft designs, a round coal-bin with lid and fittings in polished brass or chromium plate, and an extending kerb, and two Mastercraft companion-sets, are now being made in Stelvetite in the same range of colours.

New Members for SIMA

THE continued expansion of the Scientific Instrument Manufacturers' Association of Great Britain (SIMA), Sima House, 20, Queen Anne Street, W.1., is evident with the following new members recently elected by SIMA Council:—

Wilkinson Sword Co. Ltd., Sword Works, Southfield Road, London, W.4.

Claude Lyons Ltd., 76, Oldhall Street, Liverpool, 3.

Bruce Peebles and Co. Ltd., Tay Works, Bonnington, Edinburgh, 6.

Nazard, Ltd., Belmont, Surrey.

Amplivox Ltd., Wembley, Middlesex,

and B. and R. Relays, Temple Field,

Harlow, Essex, have been elected as

associate members. This brings the

total now to 149 full members and

30 Associate members, making a

total of 179 firms in SIMA.

CHANGE OF TELEPHONE NO.

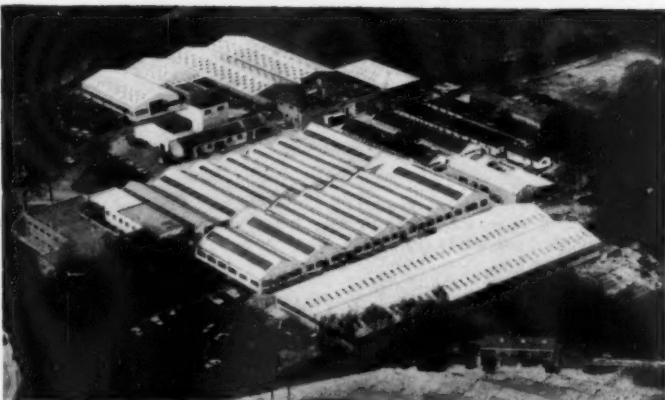
The Incandescent Group announces that their London Office telephone number has been changed from Sloane 7803 to Belgravia 7803-5.

The London Office has recently been enlarged to accommodate the rapidly increasing amount of business transacted there for members of the Group. The address—16, Grosvenor Place, London, S.W.1—remains unaltered.

NEW PLANT FOR PHOSPHATE PROTECTION

Hellermann Ltd. Extend Crawley Works

*Aerial view of Crawley Works of
Hellermann Ltd.*



SINCE Hellermann Ltd. moved to Crawley from Oxford in 1948 there has been continuous need for more space. The most recent newcomer to the Company's manufacturing Divisions, the Phosphate Protection Division, has now added its own requirements to those of the others in order to satisfy the rapidly increasing demand for its metal treatment solutions.

Originally incorporated in 1958 as Phosphate Protection Limited, a separate company within the Bowthorpe Holdings Group, the Company's activities were absorbed into Hellermann Limited as a division of that Company in 1959. The additional factory space now being erected at Crawley will incorporate modern bulk storage of raw materials to increase and facilitate production. Demand from the North of England has now reached such a level that it has proved necessary to open a storage depot in Sheffield, from which deliveries of any process from the extensive "Fospro" range can be made with the minimum of delay.

The Phosphate Protection Division has a backing of a first-class laboratory with modern facilities for the physical and chemical testing of materials, which is equipped to carry out extensive and controlled corrosion test programmes, the laboratory being staffed by fully qualified technologists.

The divisions offers to industry a range of metal-treatment processes under the trade mark "Fospro" including the conventional iron, manganese and zinc phosphates. New production techniques have insured that the solutions give not only high quality coatings but also have advantages in that in use they are less prone to presenting sludge problems. Suitable solutions are available for corrosion resistance, paint bonding deep drawing operations and electrical resistance whilst there is also a complete range of complementary pickling solutions, dyes, oils, corrosive inhibited lubricants for use in conjunction with the "deep drawing" phosphate sealants, some using conventional bases and others using the

newer forms such as using epoxy-resins and a range of degreasing materials.

A planned research and development programme emphasizing the advantages of the laboratory facilities has produced two notable achievements in the last 18 months. First a range of phosphating solutions, which produce conventional phosphate coatings without inconvenience and expense of prior degreasing. Immediate savings in expensive factory floor space, plant and chemicals are evident, whilst there are also substantial savings in view of the greatly reduced losses by evaporation. Both static and semi-automatic plants have been in operation for up to 12 months, with completely satisfactory results.

The second notable achievement is the production of a phosphate solution capable of providing a satisfactory paint bond up to a temperature of 800°C. Where in the past components have been painted in the factory and within a

space of half an hour after going into service the paint has been removed, experience can be quoted where the paint has still been in good condition after 2000 hours.

The crystalline structure of the coating remains unaltered up to much higher temperatures and it has been found possible to argon-arc weld material phosphated by this process without damage to the coating except on the actual line of the weld.

The "Fospro" range of treatment solutions are fully AID approved as conforming to DEF 29. They are also fully Admiralty approved. The manganese phosphate based solution has also been approved for compatibility with explosives under section 5, 6 and 8 of specification HR 394.

Both the activities of Bowthorpe Holdings Ltd., and the other activities of Hellermann Limited have contributed to the success of the Phosphate Protection Division. The Group, with its wide interest in the electrical engineering field, has led to the application of phosphating to the electrical industry, whilst the long experience of Hellermann Ltd. in rubbers, synthetic rubber and plastics has enabled many specialised combination phosphate/plastic finishes to be developed.

The Group's sound engineering basis is employed in the design, manufacture and installation of processing plants. These may be either static, semi-automatic, automatic immersion or spray types. The availability and close co-operation of specialised experienced staff in both engineering and metal treatment

Continued on page 208)

METAL PRE-TREATMENT PLANT FOR COMMERCIAL VEHICLES

A NEW department has just been placed in operation at the Farington factory of Leyland Motors Ltd. It will provide protection from corrosion on practically every bus and truck component, so giving immediate and long-term benefits to customers. All cast-iron and malleable cast-iron components going through the department are being shot-blasted, painted, and force dried. Steel components such as crossmembers, flitches, bumpers etc. are going through a phosphating process.

Situated in part of the old engine production plant and covering an area of over 7,000 sq. ft., the new department has ample stillage space.

Shotblasting

Shot-blasting is carried out by a giant 4-table Wheelabrator, in which the abrasive is thrown on to the iron components by centrifugal force. The components are placed on the revolving circular tables of the machine, the tables themselves being mounted on a revolving base which, when set in motion, carries the components behind a rubber curtain and through the shot chambers, returning full circle to the loading point.

From the Wheelabrator, the iron components are then placed on a continuous overhead conveyor which carries them at 4 ft. per min. past a water-wash paint-spray booth and through a 15-ft. long infra-red stoving oven. They are sprayed with red oxide of iron zinc chromate primer conforming to DEF.1035B, and passed through the oven at a temperature of 450°F.

Phospherating

Phosphating is carried out by the immersion method, making use of four baths arranged in horseshoe shape served by five 10-cwt. electric cranes on an overhead runway. The four baths are gas-heated and each has an effective compartment size of 12 ft. by 3 ft. by 3 ft. Steam is drawn off the tops of the baths by vents alongside and exhausted through a trunking arrangement with a 30 in. diameter multi-vane fan.

The steel components for phosphating are first de-greased in a tank which contains trichlorethylene vapour and then placed in a second bath containing a phosphating solution conforming to DEF.29. Independent of bulk, the components are immersed for 20 minutes at a solution temperature of 210°F., and are given a rust inhibiting coat of iron phosphate.

Next come rinses in the two final baths at a temperature of 180°F. After rinsing and drying, the components are transferred to the paint spray conveyor.

AMERICAN LINK FOR WOLSTENHOLME

MR. P. L. M. Rink, Chairman of Wolstenholme Bronze Powders Ltd., of Bolton, Lancs., has announced that the American Marietta Company of Chicago, Illinois, have acquired a minority holding in the Company. American Marietta, with vast technical resources at their disposal, have been invited as partners for the sole purpose of strengthening Wolstenholme's important position on the American Continent.

Mr. Don O. Noel, president of The Metals Disintegrating Division of the American Marietta Company, who have acted as Wolstenholme's agents and distributors in the U.S.A. for about ten years, has been elected to the Board as the representative of the new shareholders. The control, management and policy of Wolstenholme in the U.K. will remain unaltered.

Licence Agreements for Electropolishing Arranged with German Firm

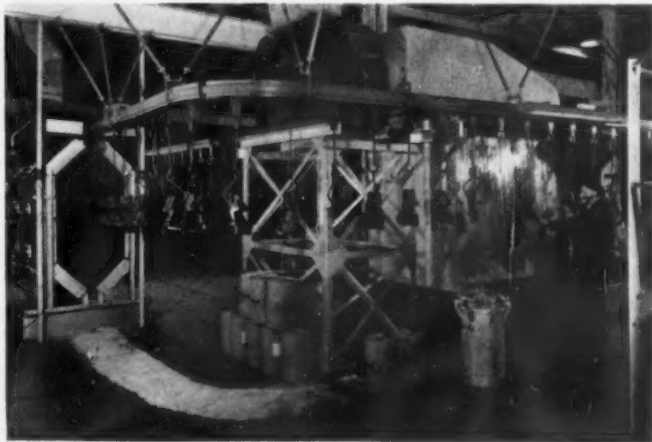
MODERN Electrolytic Patents and Processes Ltd., Mark Road, Hemel Hempstead, Herts., pioneers in electropolishing (in the U.K.) announce that their associates in Germany, Elektrolyse, Gesellschaft m.b.H. of Munich have concluded licence agreements with two well-known plating supply houses: Friedrich Blasberg, and Deinert and Co.

Elektrolyse have for some years been the largest supplier of electropolishing plants and chemicals in Continental Europe. Blasberg and Deinert and Co. are internationally known as suppliers of automatic equipment. Their experience in this field should now provide industry with up-to-date automatic electropolishing plants.

Under the agreement Elektrolyse, Blasberg and Deinert will supply the well-known Poligrat electrolytes to German industry. The agreement provides further for a pooling of experience and information for a central technical service which should benefit all users of electro-polishing.

The electropolishing processes covered by this new agreement have been developed by Battelle Institute in the U.S., the Jacquet Hispano Suiza Group in France and Elektrolyse G.m.b.H. in Germany: they are identical to those offered by M.E.P.P. Ltd.

The photograph below shows a general view of the pretreatment plant of Leyland Motors Ltd., for commercial-vehicle components.



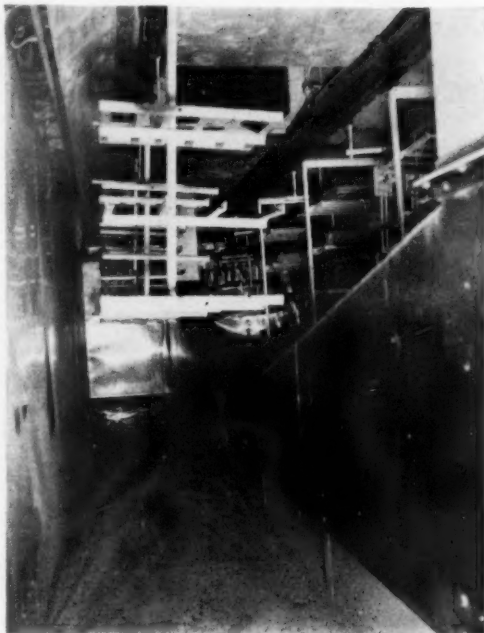
NEW STOVING TECHNIQUE FOR W. & T. AVERY

PHOTOGRAPHS reproduced on these pages illustrate a gas-fired forced-convection paint stoving oven for the continuous drying of spray-painted components at the Sherburn-in-Elmet factory of W. and T. Avery Ltd., the well-known manufacturers of weighing, testing and measurement equipment. Until recently, the oven, which has been in use for many years, had been heated by natural convection using steam radiating panels, but the introduction of new and improved paints, demanding higher curing temperatures and a shorter heating cycle, led Avery's to seek a new stoving technique since the methods formerly adopted had become insufficient.

Among the concerns approached on the subject was the Industrial Section of the Wakefield Group of the North Eastern Gas Board who submitted a design which proved of considerable interest to Avery technicians and management as their proposed design made it practicable to retain the basis of the main structure of the existing oven, which was of sound construction.

The oven is 36 ft. long and 9 ft. high and incorporates a double traverse of the mechanical mono-rail conveyor system, which is a feature of this modern and well-equipped factory. The new equipment consists of two indirect-fired heaters served by two centrifugal fans each of which pass 2,000 cu. ft. of air per minute through the heaters; the air is then delivered to special distribution channels within the oven and then released at low velocity and at a low level allowing work to be treated almost down to floor level; the bulk of the air is returned to the heaters for re-use through a central off-take where sufficient fresh air is admitted to purge the oven of paint volatiles. The heat exchangers consist of 25-3 in. M.S. tubes the ends of which can be seen under the suspended flue canopy and the burner concealed by the lift-off panels is specially designed for quick removal and is fitted with stainless steel bray jets. Under working conditions, the plant is started by an electric time switch $\frac{1}{2}$ hr. before the beginning of the working day so that working oven temperature is available for paint-spraying operations at the start of normal working hours; thereafter, temperature is maintained by means of a Kent Recorder Controller which can be pre-set to suit any demands of the work going through the oven at any particular time. The heating is fully automatic and incorporates electric ignition of the burners, thermo-electric flame failure protection and a safeguard against fan failure. Coloured signal lamps in-

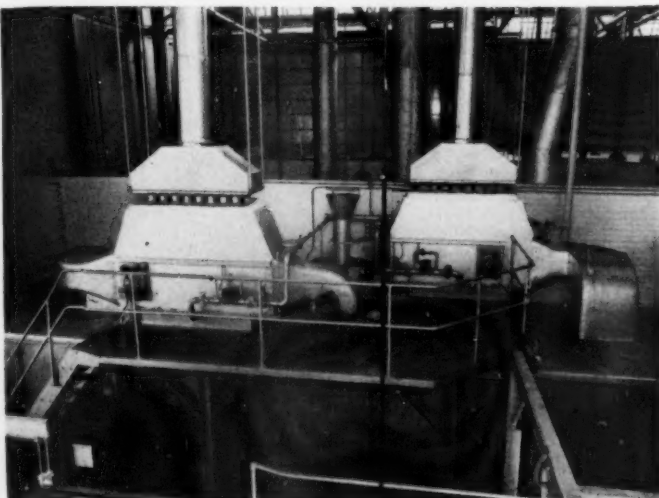
*Interior view
of plant*



dicate when the gas valves operate and similar lamps on the flame failure pilots serve to give early warning should any fault occur. The oven is of double cased construction and the inside is lined with light-gauge aluminium sheet with the exception of the floor which is of 1 in. marinite.

The heat exchangers and air trunking, as well as canopies and flue equipment, were constructed at

the Gas Board's industrial workshops and were installed, together with fans and other equipment during a Bank Holiday works shut-down. The Gas Board's work was lightened by the fact that W. and T. Avery Ltd. carried out the modifications to the oven interior and erected the staging and stairway giving access to the heaters and fans for maintenance purposes and for adjustment of controls.



Layout of top of oven

TECHNICAL and INDUSTRIAL APPOINTMENTS

FRANK M. Ryan, director of **Norton Grinding Wheel Company Ltd.**, Welwyn Garden City and vice president and general manager of Norton International Inc. has retired after more than 46 years with the company. Earlier in his career he was for a time works manager of the English factory.

Arnold W. Lee, managing director of Norton Grinding Wheel Co. Ltd., has been appointed to the board of directors of **Behr-Manning Ltd.**, Belfast, an associated company manufacturing coated abrasive products. Norton Grinding Wheel Co. Ltd., is responsible for the marketing of all Behr-Manning coated abrasives throughout the U.K.

Mr. T. J. MacArthur has resigned from the board of **Stewart and Gray Ltd.**, vitreous enamellers of Mitcham, Surrey, and will relinquish his position with that company with effect from June 30.

Escol Products Ltd. have appointed Mr. J. Lamont to the frit production staff.

Mr. Lamont attended the Paisley Technical College where he obtained a distinction in Higher National Certificate. Mr. Lamont started training in the laboratories of Carrongrove Papermills, this was followed by five years in the central laboratory of Allied Ironfounders and later with the Imperial Chemical Industries Metals Division, Birmingham.

With effect from April 4, all articles manufactured by the Fleming/B.A.O. group of companies which are intended for industrial consumption have been planned to be marketed through one subsidiary known as **Optoshield Ltd.** Mr. C. J. Williams has been appointed general sales manager of the new company and Miss B. P. Park the safety sales manager.

The name of J. and R. Fleming Ltd. has been well known for many years for the manufacture of high-quality industrial eye protective equipment and the technical representation in matters relating to industrial accident prevention remains with the Safety Division of the company as before.

At the annual general meeting of the **British Rubber and Resin Adhesive Manufacturers' Association** held in St. Albans on April 7,

1960, the following officers were elected for 1960-1961:

Chairman—Mr. N. G. Bassett Smith,
Dunlop Rubber Co. Ltd.
Vice Chairman—Dr. H. Simon,
Evode Ltd.

* * *



Mr. A. W. Lee

Mr. George Beebee has been appointed comptroller of the British Divisions of **Yale and Towne** in succession to Mr. John O. Sewell, the new general manager.

Mr. Ivor A. Bailey has been appointed deputy chairman of **The Mond Nickel Co. Ltd.** and of **Henry Wiggin and Co. Ltd.** and Mr. Edward Vaughan has been appointed director of both companies.

Dr. A. J. P. Martin has resigned his appointment as director of research with **Griffin and George Ltd.**, Ealing Road, Alperton, Middlesex, in order to concentrate his efforts on fundamental research work and is succeeded by Mr. R. C. Palmer, M.A. (Cantab) who has been his deputy. Dr. Martin will continue to act as consultant to the company.

George Kent Ltd. announce the appointment to the board of directors of Mr. John F. Willsher, general works manager.

Mr. Willsher, who is married and in his early forties, joined the Company in 1947 on his release from the Army with the rank of Captain. Four years later he was appointed production controller and, the following year, production manager. He held the post of instrument division manager from 1955 until early 1959, when he succeeded the late Mr. J. Horridge as general works manager.



Mr. J. F. Willsher

Mr. Willsher has a great interest in local management affairs and served on the council of the Luton Management Association for a number of years; he is now a representative member of the British Institute of Management, local branch.

Spencer Chapman and Messel Ltd. and its subsidiary, **Theodore St. Just and Co. Ltd.**, announce a number of changes in their boards of directors. These follow the recently announced acquisition of the whole of the share capital of Spencer Chapman and Messel Ltd. by Borax (Holdings) Ltd. and F. W. Berk and Co. Ltd.

N. J. Travis, T. A. Mason, N. C. Pearson, F. A. Rivett, C. H. Tanner and J. D. Tennant have been appointed directors of Spencer Chapman and Messel Ltd. Mr. H. Heathcote has resigned from the board and from the chairmanship. Mr. Travis has been elected chairman and Mr. Mason has been appointed joint managing director with Mrs. E. Heathcote. Mr. S. F. G. Bird continues as sales director.

New appointments to the board of Theodore St. Just and Co. Ltd. are N. J. Travis (as Chairman), R. J. Asheton, R. E. Berk, W. G. Loos, N. C. Pearson, C. H. Tanner and J. D. Tennant. Mr. H. Heathcote, Mrs. E. Heathcote and Mr. S. F. G. Bird have resigned from the board, while Dr. H. R. Soper continues as managing director.

GOLF TROPHY

THE John Preston Golf Trophy and the Alan Jordan Cigarette Casket will be played for on Monday, May 30, at Handsworth Golf Club, Birmingham. The match will begin at 2 p.m. and further information can be obtained from G. A. Jordan and Co. Ltd., 55, George Street, Parade, Birmingham 3. (Tel.: Central 7263).

Trade and Technical Publications

Midland Silicone News published by Midland Silicones Ltd., 68, Knightsbridge, London, S.W.1., indicates the wide use to which silicones can be applied successfully. Because of their high heat resistance they have made possible, for example, a new class of insulation, which has many times the life of conventional insulation with a reduction also in size and weight. These attributes have been of advantage in the building of electric locomotives for South African Railways, where the 3-ft. 6-in. gauge places a restriction on the space available for the motors.

Translation and Technical Information Services of 32 Manaton Road, London, S.E.15., have produced a bibliography "Paint Removers" — a bibliography of chemicals and formulations, which refers to most of the post-war literature dealing with paint removers and since paint removers have been a popular subject for patents in the United States, is heavily weighted with a patent section referring to applications covering methods adopted and developed in that country. The publication deals with the general behaviour of solvents, of which methylene chloride is referred to as the principal, and lists them, together with their thickening and activating agents with references to their relevant literature.

A brochure has been received from the Cumbernauld Development Corporation referring to the industrial potential at Cumbernauld New Town which is the most recent New Town designed by the Government under the New Towns Act to assist in relieving overcrowding and congested conditions in the City of Glasgow.

The site of the new town is about 14 miles equidistant from Glasgow, Stirling and Grangemouth and is designed for a target population of 50,000. It is served by rail by the main line Carlisle to Stirling and lies at the point of convergence of the A.73 road from Carlisle and the A.80 road, Glasgow to Stirling.

Imperial Chemical Industries Ltd., (Metals Division) have produced a pamphlet called "Titanium for Jigs" in which methods for using titanium in assembling jigs to be used in the

anodizing, electro-polishing and galvanizing processes are recommended.

Titanium is as strong as steel and has an elastic modulus 50 per cent. higher than aluminium and while the initial cost of titanium jigs for anodizing is higher than aluminium, this cost is recoverable within a few weeks by the saving in repairs to jigs, recycling of articles imperfectly anodized because of damaged contacts and the fact that no racks need be held in reserve. Titanium jigs used for galvanizing carry over less metal, thus helping to keep the dipping acid fresh and active, and will last almost indefinitely in most commercial electro-polishing solutions.

Leaflet M.10A issued by Metallic Furnaces Ltd., Cornwall Road, Smethwick, Staffs., illustrates three types of fusing furnaces produced by them for the vitreous enamelling industry.

The batch type with a hearth area of 12 ft. by 4 ft. 6 in. has a connected rating of 300 kW, and a combined throughput of 2 tons per hour gross; the continuous U-type recuperative furnace which is now established for large-scale flow line production has a total rating of 650 kW with separately controlled zones and a throughput of 6000 lb. per hour; the third type is the small mesh-belt continuous furnace designed initially for the badge enamelling industry.

The company have also issued a paper entitled "Electric Furnaces For Fusing," by Mr. H. Bryan which should be of particular interest to enamellers. The paper sets out the advantages the electric furnaces have over fuel-fired furnaces quoting among other things the cleanliness derived from the elimination of products of combustion, the small amount of maintenance required, simplicity of control, elimination of scrap arising from firing routine and economy in power. A case mentioned in support of economy is that of a 10 ft. by 4 ft. 6 in. electric furnace with a gross output on cast iron of 15 cwt. per hour and working a 120 hour week, which replaced a similar town gas-fired furnace, originally for the purpose of improving working conditions and finish, and created a saving in fuel costs of £1,000 per annum. A discourse is also given on the principals of design and construction recommended for electric furnaces.

Imperial Chemical Industries Ltd., Heavy Organic Chemicals Division, Billingham, have published a leaflet entitled "Thermex" Heat Transfer Medium. Thermex is a eutectic mixture of diphenyl oxide and diphenyl in the respective proportions by weight of 73.5 per cent. and 26.5 per cent., and the combination of its physical properties make it particularly suitable for liquid-phase and vapour-phase heating and cooling in a variety of industrial processes. It has a boiling point of 255°C., a low freezing point of 12°C. and excellent thermal stability over long periods at temperatures up to 400°C. It has high heat transfer coefficients, particularly in the vapour phase, and is non-corrosive, has no toxic effects on humans and a negligible fire risk. Thermex operates at low pressures at high temperatures; for instance, at 250°C. it is still in the liquid phase and at atmospheric pressure when steam has a gauge pressure of 565 lb. per sq. in. while at 350°C. its working pressure is 80 lb. per sq. in. and the gauge pressure of steam is 2385 lb. per sq. in. In vapour-phase heating, very accurate temperature control can be achieved by regulating the pressure.

The British Titan Products Co. Ltd., of 10 Stratton Street, London, W.1., publish a brochure giving specifications of all grades of anatase and rutile titanium pigments. The rutile grades have properties which make them suitable for industrial finishes, exterior paints and undercoat paints, and emulsion paints whilst the anatase grades are especially suitable, among other things, for ceramics, vitreous enamels and stoving enamels.

New plant for

Phosphate Protection

(Continued from page 204)

solutions under one roof ensures that the maximum advantage is taken in designing plant which exploits all the advantages of the solutions in reducing plant size and cost. Plant may also be readily "Tailored" to meet customers special needs, having regard to the space available and the throughput required. With its own specialist team of technical representatives throughout the country, the Phosphate Protection Division of Hellermann Ltd. is ready to advise on metal treatment problems and the appropriate plant requirements at short notice anywhere in the United Kingdom and the Republic of Ireland.

Latest Developments

in

PLANT, PROCESSES AND EQUIPMENT

Czechoslovakian Polarographic Instruments

THE following polarographic instruments are exported by KOVO, the Czecho-Slovakian State Import/Export organization for the scientific instrument industry and are sold and serviced in this country by Nash and Thompson Ltd., Hook Rise, Tolworth, Surbiton, Surrey.

P576 Polarograph.

The KOVO P.576 Polarscope is an oscillograph specially adapted to polarographic analysis. The method is based on the principle of an electrode system through which is allowed to pass an a.c. of 50 c.p.s. from a 300-V power supply of high internal resistance; the polarizable electrode is charged during one cycle of the a.c. within a potential range from 0 to -2V, and then back again from -2V to 0 (depending on solution composition). The electrode process is shown on the CR tube, where the course of the potential derivation with regard to time (vertical direction) is shown depending on the electrode potential (horizontal direction).

Adjustment of the instrument is very simple. The results can be observed immediately after adjusting a suitable intensity of the a.c. current, the d.c. component and setting the required size, brightness and sharpness of the picture. The oscillogram shown on the CR tube is oval in shape for a pure basic electrolyte, the upper half representing the cathodic, and the lower half the anodic process. Following the introduction of a depolariser into the electrolyte, the curve shows incisions in both anodic and cathodic parts. The depth of the incision is proportional to concentration and its position is characteristic of the depolarizer. The mutual position of the cathodic and anodic incisions is a measure of the reversibility of the electrode process. If they are situated at the same potential, the process is reversible; if displaced horizontally, or if one of them is absent, the process is irreversible.

The instrument is suitable for analysis in the range 10^{-3} to 5×10^{-6} M. Concentrations down to 10^{-9} M can be reached by electrolytic concentration (turning the "micro" switch on the instrument) or by a hanging drop method. Comparative titrations can be performed by using twin-electrode systems and observing two oscillo-

grams displaced horizontally. Titrant is added until the depth of incisions coincide. Isomers and compounds of similar structure can be very easily examined and identified.

Overall size is approximately 10 x 14 x 14 in. and a mechanical drop time controller is accessory to the instrument.

LP.54 Manual Polarograph.

The LP.54 Manual Polarograph is conventional d.c. Polarograph with one unusual feature which makes it semi-automatic. A recorder is built into the instrument, and light reflected from the galvanometer shines on the nearly transparent paper from behind. The knob which increases the voltage across the electrolyte cell also advances the recorder paper; one can thus plot the polarogram directly on to the paper. Sensitivity is similar to other d.c. Polarographs. Overall size is approximately 11 x 15 x 9 in.

LP.55A Polarograph.

The LP.55A Polarograph is a photographic recording instrument of a type not manufactured in the U.K. A sensitivity of 0.1 μ -amp. full scale deflection is obtained by suspending its galvanometer on a cantilever 3 ft. above the instrument. Operation is motorized and fully automatic, once the voltage range that it is required to scan has been set on the instrument. Automatic recording of abscissae after every 100 or 200 mV is performed, so that the photographic record can be easily evaluated. Approximate size is 18 x 13 x 11 in.

Telescopic Plug Valves

A NEW type of plug valve, manufactured from plastics, and being marketed by Goodburn Plastics Ltd., Arundel Road, Uxbridge, Middlesex, embodies a new design which eliminates the use of a diaphragm and since no packing gland is incorporated, requires no servicing.

The valve stem is housed in two telescopic-type sleeves, which slide inside each other, the outer forming a reinforcement to a soft rubber cup which makes the seal. By turning the handwheel, the stem forces the rubber cup and the outer reinforcing sleeve to the bottom of the passage; the rubber cup is then compressed and due to its flexibility seals on all sides against the walls of the casing.

The working pressures are up to 145 lb. per sq. in. and the valves should be suitable for temperatures up to 140°C.

The design is protected by German and foreign patents.

Improvements in Cleaning Techniques

SEVERAL makes of machines are available in which simple agitation and the theory of cavitation has been employed to take the place of the laborious and time-wasting method of hand scrubbing parts.

Among the range of agitating machines produced by The Magnus Chemical Co. Ltd., Uxbridge,

Middlesex, the Magnus "Porto-Lif" (Fig. 1) provides a simple and economic means by which a tank or drum can be converted into an efficient cleaning machine. It consists of a tray in which up to 75 pounds of parts can be cleaned thoroughly at one time. The work is forced through the solution over 100 times per minute and since the apparatus is operated only by compressed air, costs of operation and maintenance are low.

In the "Rapiclean," Fig. 2, which is manufactured by Ultrasonics Ltd., Westgate Otley, Yorks., vibrations in the cleaning solution are produced by a magneto-strictive transducer at a chosen frequency of 13 kilocycles. As the transducer is unaffected by temperature, it is possible to work beyond the boiling point of water. The capacity of the beaker, situated on top of the cabinet, is 100 cm.³

Fig. 1—"Porto-Lif" cleaning machine

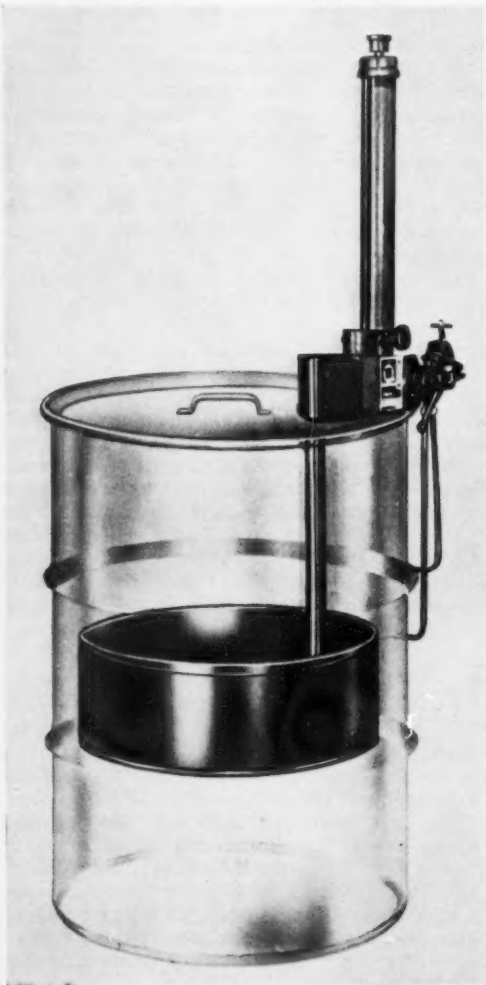


Fig. 2—The "Rapiclean 1" manufactured by Ultrasonics Ltd.

Fig. 3 is an example of cleaning equipment produced by Kerry's (Ultrasonics) Ltd., Stratford, London, E.15., for the removal of tenacious contaminants such as polishing compounds, abrasives etc. from a large range of components including jewellery, ophthalmic equipment, diesel injector parts, cutlery etc. Irradiation is imparted to the cleaning solutions by generators and transducers at ultrasonic frequencies, i.e., 20Kc/s, 40 Kc/s

(Continued in page 212)

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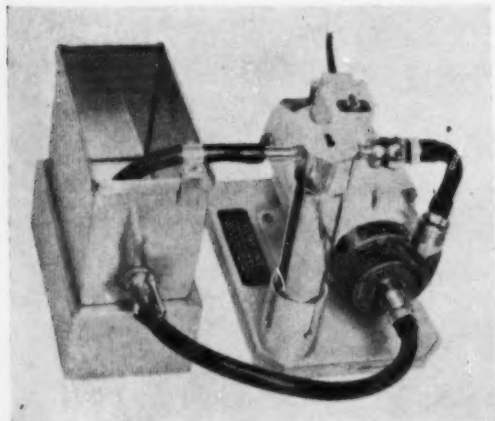
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Fig. 3—High-power 2-stage Ultrasonic Cleaning Cabinet manufactured by Kerry's (Ultrasonics) Ltd.



or 1 M/c according to the application, although normally equipments are supplied for use at standard 40K c/s. Units for use with aqueous-based solutions are available with optional water rinsing facilities and continuous fine filtration or where chlorinated solvents are to be employed the units are supplied with optional solvent redistillation recovery and vapour drying and multiple fine filtration. The inclusion of filtration equipment is desirable since the cleaning solution becomes loaded with suspended dirt and has to be renewed at frequent intervals, depending on the state of the components to be cleaned. Apart from the waste of time, the repeated renewal of solutions which are still active can be very expensive.

Fig. 4—Dawes Type 1181 Filter Unit.



The Type 1181 Filter Unit, Fig. 4, produced by Dawe Instruments Ltd., London, W.5., has been designed for the continuous removal of solid matter from ultrasonic cleaning baths of their own or other design. Fluid is drawn from the bottom of the bath by a centrifugal pump driven by a 200-W electric motor and returned to the bath by way of a cylindrical filter having a sintered element of stainless steel capable of removing all solids down to a size of below 2 microns from 8 gallons of liquid per hour. Coarser filter elements can be substituted to give flow rates as high as 60 gallons per hour. The overall dimensions of the unit are 12 in. by 6½ in. by 10 in.

Plating Cylinder

THE Hanson-Van Winkle-Munning Company, Matawan, New Jersey, U.S.A., announces the availability of a plexiglas, belt-driven plating cylinder *i.e.* the new H-VW-M-Mercil Model 59 plating barrel cylinder. The unit's motor drive is mounted directly on the pulley shaft and hanger assembly and is available for 220- and 440-volt supplies.

The newly designed cylinder effects tow important savings, according to the manufacturer. Because the cylinder rotates constantly there is less dragout from tank to tank. This reduced dragout also means thorough rinsing of the work. The second saving is realized in applications where there are a large number of tanks and a relatively small number of cylinders. Because each cylinder has its own motor drive, the need for tank motors is eliminated and therefore the total number of motor drives is reduced.

(Continued in advt. page 29)

Plant, Processes and Equipment

(Continued from page 212)

Two New Polyester Surface Coating Resins

THE production of two new "Epok" polyester surface coating resins, one wax free and the other wax containing, is announced by British Resin Products Ltd.

Epok A.3901 is a solution of a polyester resin in styrene and contains a small percentage of dissolved paraffin wax. When mixed with a peroxide catalyst and metal promoter, the resin will harden throughout and thin films in contact with air will be tack free in a few hours at room temperature.

Epok A.3904 is a wax free air drying polyester resin. As with A.3901 the resin is mixed with a peroxide catalyst and metal promoter before use to give a lacquer. Curing can be accelerated by using infra-red heating.

Lacquers based on these resins have excellent flow properties and are free from cissing and catering. Ease of sanding ensures low abrasive paper consumption. The resins confer a high gloss, excellent mar resistance and a high build is obtainable on a single application. They are rapid drying and whilst giving a very hard coating they retain a degree of flexibility which minimises tendencies to lift or crack.

A.3904 is particularly suitable for pigmented coatings and both resins are ideal for application on wood, hardboard, asbestos, metal, paper and plasterboard.

Information sheets No. E. 120 on Epok A.3901 and No. E.121 on Epok A.3904, can be obtained from Information Department, British Resin Products Ltd., Devonshire House, Piccadilly, London, W.1.

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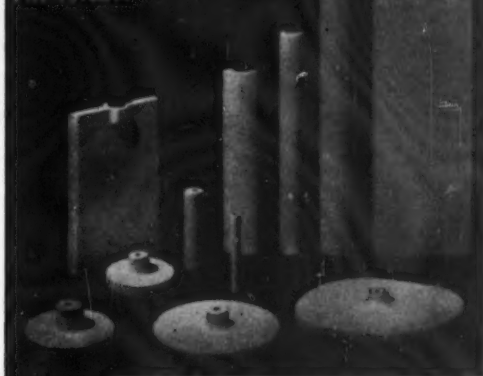
COMPLETE ANODISING PLANT. Transformer, Davensett Rectifier (20 volts 300 Amps), plus various lead lined, rubber lined and mild steel tanks. Also 7 stainless steel tanks suitable dyeing (2 gas heated). G.B. Fasteners Limited, Conington Road, Lewisham, S.E.13. Lee Green 9971/2.

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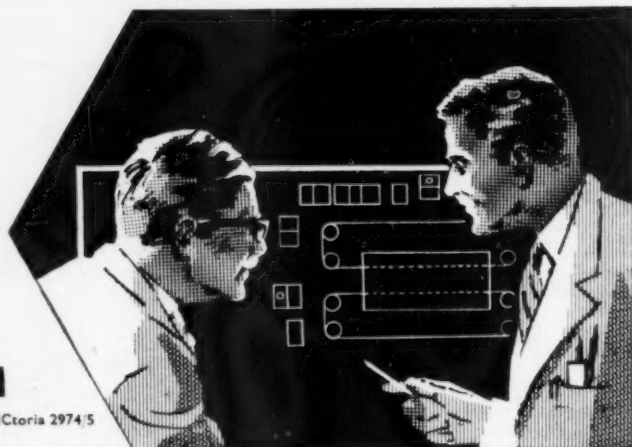
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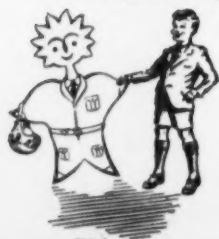
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